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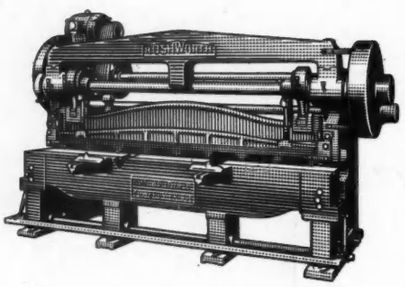

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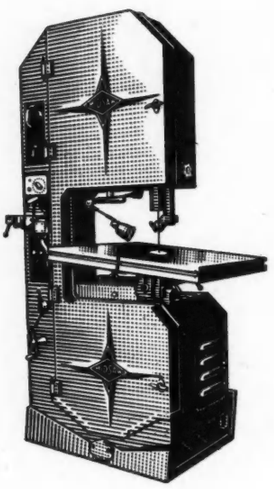

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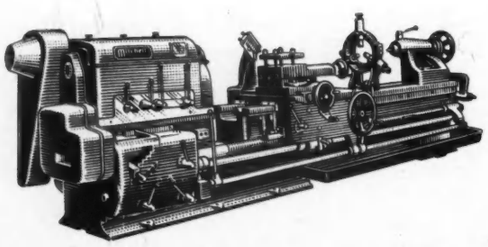

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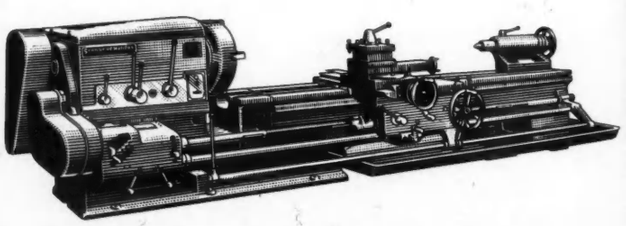

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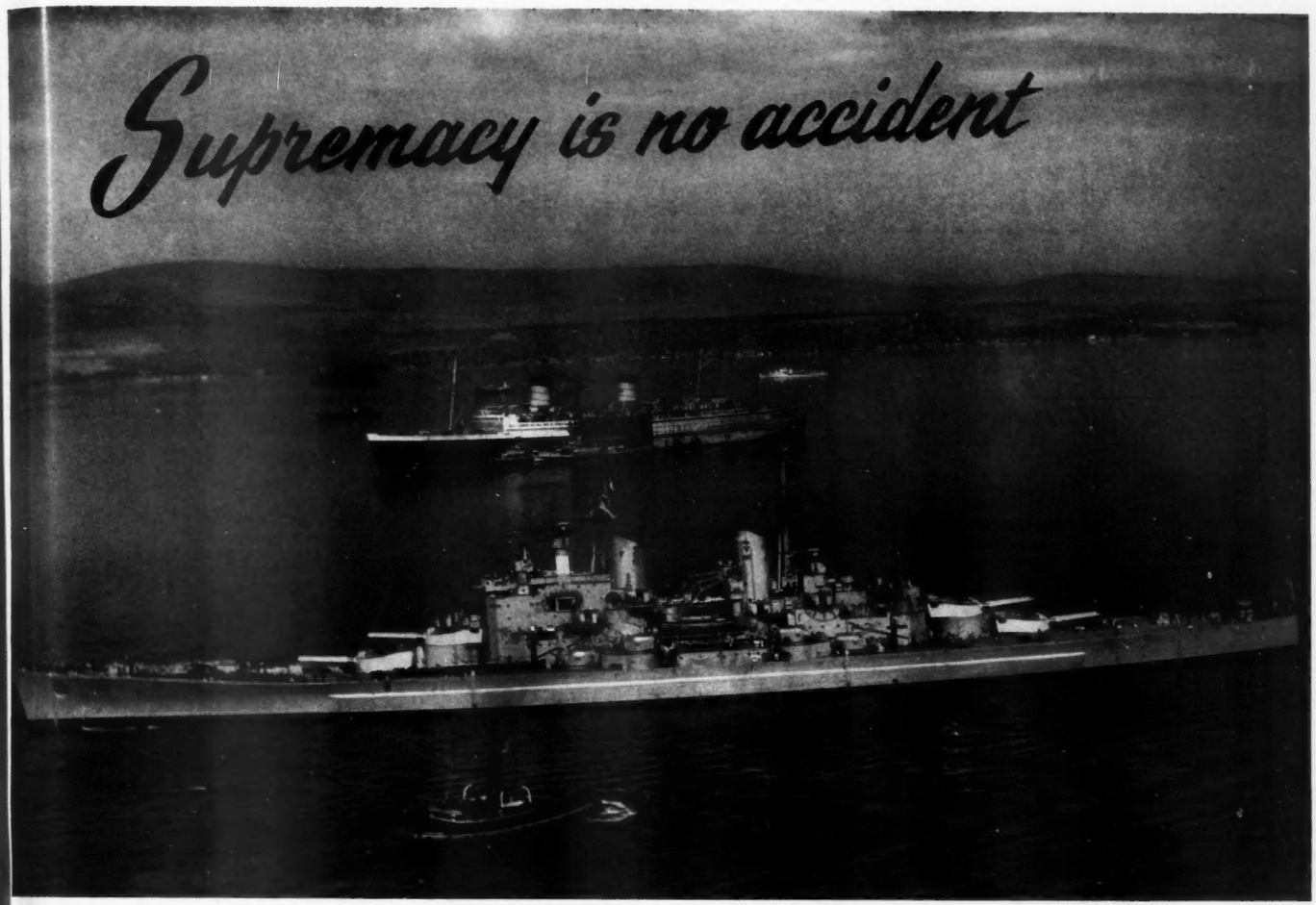

Photograph by courtesy of "The Bulletin", Glasgow.

The "Queen Elizabeth" and "Vanguard" at anchor in the Clyde, are two fine examples of the supremacy of British shipyards.

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An Illustrated Weekly Journal

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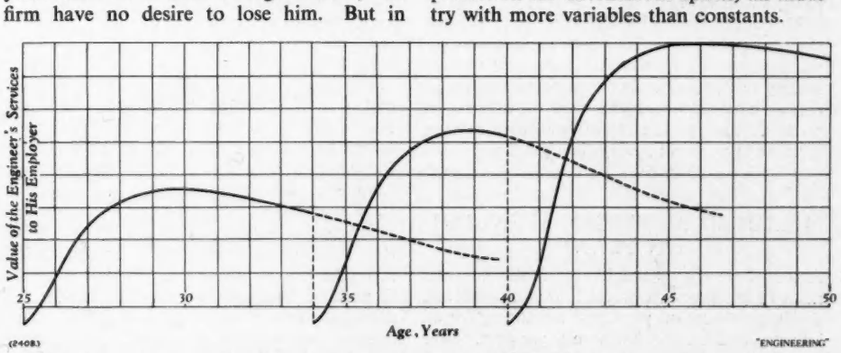
THE VALUE OF CHANGE

SOME of the most important decisions in life are taken without benefit of advice or education. In making up his mind the individual cannot rely on any accepted formula, nor on principles learnt at school or university. All he can do is to weigh up the pros and cons, try to assess the future consequences, and then take the irrevocable step. What factors, for example, should be considered in the decision to move from one professional post to another? The same problem, but in another form, is never far from the minds of those who are responsible for engaging new staff.

First, engineering never remains static. Its organisation, whether in a whole branch of industry or in an individual firm, is not like that of an army or Civil Service, in which continuity and established order are of prime importance. It is a tactical rather than a strategic organisation. It must be modified to meet changing circumstances. Occasionally it must be revolutionised. The products of the engineering industry change even faster than its organisation. There are firms to-day whose products simply did not exist before the war.

Against this backcloth of ceaseless change the principal players are the engineers, newly fledged or near retiring; minor characters in the drama or at the summit of their professional ability. With the aid of the idealised graph shown below, let us trace the life work of a hypothetical engineer who starts his first job at the age of 25, leaves for something better at 34, and again at 40. His contribution to the firm employing him is measured by the vertical scale, and his age is set out along the horizontal scale. At the age of 25 his first six months or so represent a net loss to his employer. Thereafter his services increase in value, reaching a peak at, say, 30 years of age. For some years then he is held in high esteem; his firm have no desire to lose him. But in fact his value is slowly declining—imperceptibly, because the vertical scale is practically impossible to measure. Those changes which we have noted are taking place, or should be taking place, but he is becoming gradually less capable of recognising the need for them and of taking action to meet them. Fortunately, at 34 he moves to a new post. The first few months are again a net loss, but then his value increases rapidly and reaches a much higher peak than before. Another similar decline is arrested at the age of 40, when he moves to the post which proves to be the summit of his professional career.

There can be countless variations of this pattern but the general principle holds good. Most men will, indeed, change their jobs more often than twice in 25 years, and many, particularly the exceptionally successful, make a change quite late in life, perhaps never "settling down" in the way that most men do. But however short or long the interval between one post and the next, the important factor is the ability to bring valuable and varied experience to bear on old and new problems. Specialisation—the evil and the essence of an industrial society—is revealed in its true nature by this graph. It is essential in that it is necessary before an engineer can give useful service; but it becomes stultifying if it is allowed to continue for too long. Questions of policy continue to be decided on the basis of principles or assumptions which no longer apply, and only a fresh mind or a mind that has remained open can cut through the undergrowth of out-worn tradition and sow new seed. An outstanding engineer may acquire the omniscient and lively approach at an early age. If anyone can afford to remain in one post or in one special branch of engineering for a long time, he can; but most of us require the developing influences of several posts, especially before middle age. It may be hard to make a move which is not dictated by the pressure of circumstances, but engineering is a profession for adventurous spirits, an industry with more variables than constants.



A graph drawn to show the value of varied experience in the career of an engineer who changes his work at the age of 34 and again at 40.

Weekly Survey

CAPITAL INVESTMENT COMPARISONS

Since 1947, output per head in Western Europe has risen twice as fast as in the United States, and some of the considerable ground lost during the war has been made up. In real terms, however, output per head in Western Europe was only 10 per cent. higher than in 1938, while in the United States it was 70 per cent. higher. This information, and a wealth of other facts concerning the post-war economic progress of Western Europe countries, the United States and Canada are drawn from "Statistics of National Product and Expenditure, 1938, 1947 to 1952," published last week by the Organisation for European Economic Co-operation. O.E.E.C have succeeded in analysing the national income statistics of each country in such a way that broad comparisons can be made of the level of investment and output per head, which are of particular interest to engineering companies.

The proportion of each country's resources (gross national product) devoted to investment at home (gross domestic capital formation) is shown for 1938, 1948 and 1952. During 1952 the United Kingdom invested less, and consumed more, of its total resources than any other large country included in the survey. The proportion invested—12 per cent.—compares with 25 per cent. in Germany, 22 per cent. in Canada and Italy, 21 per cent. in Sweden, 18 per cent. in the United States and 16 per cent. in France. The statistics of consumption show that in 1952 the United Kingdom was consuming more than any of its major competitors—87 per cent. of gross national product compared with 82 per cent. in the United States and 73 per cent. in Germany. Yet the volume index of private consumption (1951 = 100) shows that it was only slightly higher in this country in 1952, than before the war—99 compared with 93 in 1938—whereas vast increases took place in the United States and Canada during the war and a greater rate of increase was recorded in Germany and Italy since the war. This shows clearly the magnitude of the effect of the war and subsequent rearmament on the nations which took part: it acted as a powerful stimulant to a higher standard of living in North America and was crippling in Western Europe.

The picture emerging from the domestic investment statistics shows the United Kingdom has been unable to stimulate investment on the scale of its major competitors. In North America the peak of capital investment and industrial expansion has probably been passed, whereas in Western Europe, particularly in Germany, Italy and France, the level is still rising and is likely to continue to rise.

There is no mistaking the message of the new statistics; the United Kingdom is consuming too much and investing too little compared with its leading competitors. It should be investing far more since its dependence on exports is far greater. Perhaps the recent news of a marked increase in personal savings is a good augury.

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REDUCED AMERICAN SPENDING ON PLANT

A recent survey by the United States Government of business investment intentions indicates that expenditure on plant and machinery for all industry in 1954 will be some 6 per cent. lower than last year, when it totalled 28,391 million dols. The report suggests that a decline in the outlay on capital goods is already under way but that it will be gradual. Only three major industries—transport equipment manufacture, paper machinery and petroleum—expect to spend more on plant and machinery than they did in 1953. These three industries accounted for about 15½ per cent. of total business investment last year, but the size of the increase in their expenditure is relatively small, amounting to 393 million dols. Most of this is accounted for by the transport equipment industry, which includes motor-cars. The successive falls in car output in recent months make the decision to spend more on capital equipment somewhat surprising, though there is an obvious need to maintain maximum efficiency during periods of growing competition.

The planned reductions in plant investment vary widely between industries. The biggest is being made by the railways—a reduction of 35 per cent.—reflecting both reduced earnings and the fact that post-war modernisation programmes are nearing completion. The same applies to the primary metal industries, which include iron and steel and non-ferrous metals. Steel output has been running at nearly 30 per cent. below last year's level and several companies have cooled off large furnaces. The expansion programmes started after Korea are almost completed and the industry is expecting to spend one-third less this year than last. Non-electrical engineering companies, which include some of the industries that will suffer most from the cuts, such as machine tools, textile machinery, and chemical plant, will reduce their own spending by about 13 per cent. Textile, chemical and rubber companies have planned reductions of 15 per cent. The reduction of investment in capital goods by manufacturing industry as a whole is expected to be by 8 per cent. on last year, to 11,332 million dols. It is of interest to note that manufacturers of consumer durable goods have scheduled cuts of 11 per cent. whereas those scheduled by manufacturers of non-durable goods amount to only 5 per cent. This trend in capital investment could develop into a serious threat to the stability of the United States economy. One result will doubtless be intense efforts to increase exports of machinery and plant.

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GLASGOW EXHIBITION IN RETROSPECT

The Scottish Industries Exhibition in Glasgow came to an end last week and first impressions are that it has been a success. It may be some little time before the financial details are completed and the good-will which has been stimulated for Scottish industry can be assessed in terms of prospective business. But the final verdict of those responsible for running it is likely to be favourable. It is apparent already that this Scottish exhibition, whose guarantee fund was rapidly subscribed to by Scotsmen, has brought a large number of overseas buyers and a useful number of orders. Provisional figures suggest that about £10 million worth of orders have been booked already as a result of the exhibition and that attendances of buyers have been well up to expectation, although the total attendances have been about 20 per cent. lower than at the 1949 exhibition. It is probable that the change in admission charges, and the fact that this is the second Scottish exhibition of its kind since the war, may have reduced its drawing power with the general public. There appears to have been a good spread in the orders booked, in addition to one or two large orders (one of them for road tankers for Australia ran into six figures). Good business has been done in machines, tractors, tools, rope, office equipment, clothing and carpets. Here, in fact, is an exhibition which is likely to have made a profit and to have proved worthwhile to exhibitors.

Some of the more important lessons to be learned from the exhibition, however, can only be appreciated against Scotland's recent industrial background. Local enterprise staged a notable exhibition in 1949 and has done the same again five years later. The country has constructed a shop window in which all its goods, from the heavy and light industries, have been represented. Local enterprise and local money have stirred themselves to sell Scottish industry. This is the vital fact, for it is difficult to conceive that Scottish industry could have done such a thing 20 years ago. It is true that Scottish industry is still dependent on heavy capital goods; the progress which has been achieved so far in attracting light industries is still inadequate. But it is apparent that much progress has been made, that Scottish industry has an increased will to survive, and that many old prejudices outside Scotland about setting up factories in the country have been overcome. This quinquennial event in Scotland, if such it is to become, is in fact a display of Scottish goods which carries the challenge that Scottish skill and enterprise, particularly in engineering of all kinds, is adaptable to the commercial development of any worthwhile idea.

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GERMAN SHIPBUILDING RECOVERS

The sudden and substantial increase in orders received by German shipbuilders suggests that the lull in shipbuilding may be coming to an end. In the first quarter of this year the intake of orders was only 43,000 tons, compared with deliveries averaging 180,000 tons a quarter in 1953 and 200,000 tons in the first six months of this year. Orders received during the next two months totalled 92,000 tons and during July and August 130,000 tons. The order intake during the past four months was only 8 per cent. less than the rate of deliveries last year. The decline in the industry's order book—from 1·43 million tons in January to 1·13 million tons in July—has therefore been checked. Activity in the shipyards continues at a very high level, at an annual rate of 900,000 tons, which is a fifth higher than in 1953. Employment is now the highest ever, at 85,000 compared with 206,000 in the United Kingdom yards.

The vast expansion of German shipbuilding in recent years—before the war output averaged about 400,000 tons a year, including that of Eastern Germany—resulted from the fact that at the time of the Korean war other nations' shipyards, and particularly Britain's, were booked up for years ahead. Orders were therefore placed in German yards, which had just been freed from all Allied controls. Mr. Onassis alone placed orders for 300,000 tons of tankers to the value of £25 millions. Over the past 18 months, however, the inflow of orders had fallen off considerably and the decline in order books, by 21 per cent., was the same as that registered in the United Kingdom. The fall in freight rates has considerably slowed down the rebuilding of Germany's merchant fleet, which is still less than half its pre-war size. Financing has also become more difficult although the Ministry of Economic Co-operation will probably make available reconstruction loans and "special resources" sufficient to finance a comparatively large volume of new shipping. So far, however

the recovery has been solely in export orders; the tonnage on order for German owners has declined from 612,000 tons in January to 437,000 tons in September and home orders now account for only 38 per cent. of the total order book.

The prospects of German shipbuilding are viewed very soberly by the Germans themselves. A further expansion in output is not expected and the annual average is estimated at about 600,000 tons, one-third below the current rate, of which exports would account for not more than 40 per cent. The competitive ability of the German industry should not, however, be under-rated. Some of the leading companies, such as Deutsche Werft, are receiving new orders at the same rate as that of their deliveries. Considerable efforts have been made to quicken the time taken to build ships—a most important factor if full advantage is to be reaped from any recovery in freight rates. In general, therefore, the German shipyards are becoming well equipped to fight for orders in world markets, although they will continue to be handicapped by the undisputed fact that the hallmark of quality in shipbuilding is still British.

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MANCHESTER-SHEFFIELD ELECTRIC PASSENGER SERVICE

On Tuesday, September 14, the first electrically-hauled passenger train ran from Sheffield to Manchester, inaugurating the new regular service between these cities. The event is a stage in the history of railways, for, after September 20, all passenger and most freight traffic on this line will be moved by electric locomotives. The idea of this electrification was put forward many years ago, and work was actually started before the last war. Hostilities caused an interruption, but work was resumed in 1949 and the first section from Penistone to Dunford was brought into use for goods traffic in 1952. In order to keep down the costs only seven of the express locomotives have been built (instead of 27) and the conversion of a loop-line at Manchester to Trafford Park and the Central Station, has been held over. In all, the scheme has cost some £11 millions, with an additional £4 millions for the Woodhead tunnel. Most of the stages of the work have been described in detail in earlier issues of ENGINEERING.

With the electrification, the smokey horrors of the old Woodhead tunnel will go, for all the electrically-hauled trains will use the new double-track tunnel. The faster of the passenger trains listed in the new timetable will cover the journey from Manchester (London Road) to Sheffield (Victoria) in 57 minutes. The only work still remaining to be completed is between Sheffield (Victoria) and Rotherwood sidings, which will form one of the locomotive exchange points.

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CONNAH'S QUAY POWER STATION

The Connah's Quay power station, in Flintshire, which was officially opened by Lord Citrine on September 16, is the third new station in the Merseyside area to go into commission since the war, and the first in Wales in the same period. It is also the 43rd in the whole country to go into commission during the last 6½ years. The construction involved a considerable amount of land reclamation as the site on the River Dee was originally mainly tidal saltings.

The new station will supply a total of 180,000 kW when it is completed; at present only one-third is in operation. Feeders at 132 kV link the station with Chester and Dolgarrog and part of the supply will go to the atomic energy establishment at Capenhurst. Other links go to Birkenhead and Hawarden. Coal for fuel will be brought by rail mainly from the East Midlands. An article describing the station will be published in ENGINEERING shortly.

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INTERNATIONAL CONGRESSES

It is a moot point whether the benefits derived from international engineering conferences are sufficient to justify the expense involved. Apart from the financial cost, there is the considerable time that usually has to be devoted to the purpose by senior staff. Are there corresponding commercial and technical rewards?

To some extent the answer depends on whether an international organisation already exists, which it is proposed to join, or whether the intention is to start such an organisation. If one exists, as in the case of the International Internal Combustion Engine Congress, it may be foolish to remain aloof; this was the view taken by the people who attended a meeting in London last week and decided to form a British National Committee, as reported on page 389. If one does not exist, but a proposal is put forward by certain representatives of a branch of the engineering industry, serious consideration should be given to the proposal. Britain should lead Europe, not follow on behind.

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YOUNG AND OLD

There are practical difficulties in the way of finding useful work for retired executives. The difficulties are pronounced if the first idea is to employ such men in the firms from which they have retired. But if arrangements can be made to enable a retired executive to work for another firm, there is more scope for using his experience and knowledge without embarrassment. There are many possibilities; one is to arrange for him to feed the firm with technical information culled from all the numerous sources which exist to-day. By acquainting himself with the firm's manufacturing processes, design work, etc., he can scan the hundreds of specialist publications.

Such a plan is outlined in a letter from Mr. G. W. Williamson published in this issue. Recalling an article and a letter on the subject we published over four years ago, he states the objects of the Association of Retired Industrial Executives which he has been instrumental in forming. As a member of the three major engineering institutions, a member of the Institution of Production Engineers and a Fellow of the Royal Aeronautical Society, he is well qualified to give a lead. There is already the Association of Retired Engineers, but the new body is intended to operate abroad as well as at home and to act as agents for senior executives who may not be engineers, as well as for those who are.

Mr. Williamson speaks of "educational guidance and selection methods for the coming generation." He is referring here to the possibility of guiding young men (and their parents) in the all-important business of planning a career. If something can be done in this direction it will help to solve the problem of recruitment to the engineering profession—a problem discussed at the recent British Association meeting, as reported elsewhere in this issue.

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CROSS CURRENTS IN COPPER

It has been announced from Chile that the strike of copper workers has been settled between the Government and the workers' representatives, albeit without the participation of the company's representatives. Even if this means a quick resumption of work at the mine, it will not be possible for Chile to meet her commitments of copper for this year.

The troubles in Chile have been accompanied by renewed strength in copper prices on the London Metal Exchange. In the last two weeks the cash price has advanced from about £233 a ton to £253 a ton at the end of last week, which compares with a previous "high" of £250 a ton last April. The reasons for this strength in the copper market are not far to seek. Stocks in the warehouses of the London Metal Exchange fell from 2,439 tons in the middle of August to 1,890 tons earlier this month and it is known that users of copper persist in leading a hand-to-mouth existence despite the increased use of the metal in this country. In June of this year the month's consumption of copper, including scrap and secondary metal, was 49,500 tons compared with 42,400 tons in June of 1953 and an average monthly consumption in 1953 of 37,300 tons. By May of this year, in fact, monthly consumption had gone through the monthly average consumption for both 1951 and 1952. The low level of stocks in this country, excluding the Government reserve, and the upward tendency of consumption have not, however, brought any greater confidence in the expectations of a rise in copper prices. The statistics of copper have called for firmer prices, and firmer prices there have been, but buyers cannot be persuaded that this will last and they continue to keep their stocks low. Even in the last two weeks the strong upward movement in cash copper prices has been accompanied by a slight increase in the discount on three months copper.

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COMMERCIAL VEHICLES

Overseas currency to the total of £36 millions came to this country during the first half of the year as the result of the export of commercial vehicles. In July the monthly volume of exports rose above 12,000 units for the first time in two years. It is to be hoped that the Commercial Vehicle Exhibition, which opens to-day, will set off a further round of overseas selling although there is some way to go if the monthly record, 14,298 units attained in 1951, is to be reached. Whatever the result the industry is to be congratulated on its achievement, especially because of the great variety of types that it must produce to hold the overseas markets. Considering the home market as well, it is more than likely that the manufacturers in this country are called upon to produce a wider range of vehicles than those of any other manufacturer in the world. To help reduce this variety the Minister of Transport recently announced that it is his intention to change the Motor Vehicles (Construction and Use) Regulations, 1951, to permit 8-ft. wide vehicles of increased length and axle loads to operate on the public highways in Britain.

Turning to the trends in design to be seen at the exhibition it is noticeable that economy of operation and greater payloads per vehicle are receiving first attention. More medium-class vehicles are fitted with Diesel engines, which, when used regularly over reasonable distances, offer cheaper running, overall, than the petrol engine, due to the increased mileage per gallon, reduced accessory maintenance and long life. The use of light alloys, assisted by newly developed welding techniques, and of plastics is increasing, and passenger-carrying as well as goods vehicles constructed from these materials are able to carry greater loads and reduce running costs to offset their higher first costs.

CONTRACTS

Rolling-Mill Cooling Banks. As announced on page 360 of our issue of September 17, the order for the new blooming rolling mill at the Lackenby Steelworks has been placed by Dorman, Long and Co., Ltd., with the DAVY AND UNITED ENGINEERING CO., LTD., Sheffield. This company now announce that they have received a further order from Dorman, Long and Co. for another section of their development schemes. This second order covers the supply of primary cooling banks complete with all approach and run-out tables for a section rolling mill at the Cleveland Works.

Electric Traction Equipment. The British Transport Commission have placed an order with the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, for the complete electrical equipment for 32 four-coach multiple-unit trains to operate on the forthcoming Southend and Chelmsford extensions of the Eastern Region of British Railways, Liverpool-street to Shenfield electrification scheme. The equipment is designed for 1,500-volt d.c., and each train unit will consist of a driving-trailer coach, motor coach, trailer coach, and second driving-trailer coach. The motor coaches will be powered by four axle-hung motors, with series-parallel control by underframe-mounted electro-pneumatic contactor equipment providing automatic acceleration with two full-field and one weak-field continuous running notches. The mechanical parts of the rolling stock will be built at the Eastleigh Works of British Railways.

Diesel and Dual-Fuel Engines. A large order for Diesel and dual-fuel engines has been placed with the NATIONAL GAS AND OIL ENGINE CO., LTD., by the Kellog International Corporation. This equipment will be supplied to Imperial Chemical Industries, Ltd., for driving gas compressors at their No. 2 Olefine plant, at Wilton, Yorkshire. The total power involved is approximately 11,000 b.h.p., to be obtained from 13 engines. These comprise five normally-aspirated Diesel engines of the F4A series, three pressure-charged Diesel engines of the B4AU type, and five of the latest pressure charged dual-fuel B2AUP5 units. All will be direct-coupled to reciprocating gas compressors. The dual-fuel engines will normally operate on ethane gas, but they can be changed over to full Diesel operation while running.

Aluminium-Sheathed Cable. The South-East Scotland Electricity Board have placed a contract valued at £40,000 with BRITISH INSULATED CALLENDER'S CABLES, LTD., for the supply and installation of an aluminium-sheathed 33 kV impregnated pressure cable in the Board's Fife sub-area. The 7,050 yards of three-core cable will run from Townhill power station, outside Dunfermline, to Nethertown substation. The route is a particularly hilly one and the use of this type of cable will obviate any trouble due to compound migration. The main cable consists of 0·25 sq. in. died-down screened conductors, paper-insulated and aluminium-sheathed, protected overall by a combination of PVC tapes, self-sealing rubber tapes and hessian tapes, and will operate at 33 kV. At one point the cable route passes through a loch and on this section a specially-designed long length of lead-sheathed underwater cable will be laid. A short length of solid-type cable will be used at the terminations. The cable is expected to be in commission by July, 1955.

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MARSHALLING YARD AT ALLOA

New Works in Scottish Region

British Railways (Scottish Region) have in hand a large programme of developments in marshalling-yard accommodation to hasten the transit of the increasing production from the Fife coalfields. A considerable increase in the facilities at freight-marshalling yards at Kelty and Oakley has already been provided, and work is proceeding on the construction of a new marshalling yard at Thornton to handle 3,000 wagons per day.

A fourth large project for the construction of a marshalling yard at Alloa at an estimated cost of approximately half a million pounds has now been authorised as existing facilities are inadequate for the expanding coal production in the locality, and to which the new mine at Glenochil will make substantial addition. The principal features of this new yard will be 15 sorting sidings with five reception sidings. When completed it will deal with 1,500 wagons a day.

THE "GREAT WHEEL" AT LAXEY, ISLE OF MAN

On September 27 occurs the centenary of one of the most curious engineering structures since the days of John Smeaton—the Great Wheel which was erected in Laxey Glen, Isle of Man, in 1854, to pump water out of the lead mines of the Great Laxey Mining Company. It was set to work by the then Governor of the island the Hon. Charles Hope, and, as it began to move, was named "Lady Isabella," in honour of the Governor's wife, by Mrs. George W. Dumbell, wife of the chairman and managing director of the company. It continued to pump out the mine until about 1929, when the company closed down, and is now in the possession of a local resident, Mr. E. C. Kneale, who maintains it as a historical relic and a popular show-piece. It has been described, probably with justice, as the largest overshot wheel, and possibly the largest of any type, being 72 ft. 6 in. in diameter and 6 ft. broad, and was considered capable of pumping 250 gallons per minute from a depth of 200 fathoms.

The design was by Robert Casement (1815–92) to the requirements, apparently, of the mine "captain," Richard Rowe. A plate attached to the wheel bears, in cast lettering, the legend: "Erected Anno Domini/1854/Robert Casement, Engineer/Richard Rowe, Manager." There is no doubt regarding their respective responsibilities, as the contemporary report of the inaugural ceremony, published in the *Manx Sun* of September 30, 1854, states that, in the course of the numerous speeches, "Capt. Rowe as well as the Chairman gave Mr. Casement, the engineer of the company, full credit for the ability displayed by him in designing and constructing the wheel, and payed (*sic*) a high compliment to his self-cultivated talents."

The axle of the wheel, according to the *Manx Sun*, was made of hammered iron by the Mersey Iron Works, at Liverpool; it is 17 ft. long and 21 in. in diameter. The rim is of cast-iron segments, connected by straps at the sides; they were made by Gelling's Foundry at Douglas, I.O.M. The cast-iron hub of the wheel was made at the Vauxhall Foundry, Liverpool, of George Forrester and Company, who, in the early days of John Laird's Shipyard at Birkenhead, were his principal suppliers of marine engines; Forresters' name-plate is still *in situ* on the wheel. The cast-iron segments of the rim are 24 in number and each contains seven buckets. They are connected together by iron straps and to the hub by 24 wooden arms on each side (i.e., 48 in all) and by twice that number of iron tie-rods. Half of the tie rods are crossed, like the spokes of bicycle wheels, to give lateral stiffness. At about half the radius, the wooden spokes are connected by a bracing ring of cast iron on each side of the wheel. The spokes are mortised into the hub, which is secured to the axle by wedges. The axle rests in two cast-iron bearing blocks, mounted on oak seatings on the top of the two massive stone walls supporting the wheel.

A crank on one end of the axle gave a throw of 10 ft. to a line of oak rods, joined by wrought-iron straps, which extended for 600 ft. along a stone viaduct to the mine shaft, where a bell crank connected the horizontal rodding to the vertical line in the shaft, at the bottom of which was the pump. All of this rodding except a short specimen length has now been removed. The connecting rod between the crank and the viaduct rodding is supported at its outer end by a rocking lever, and a similar lever supports the other rod, which operated a balance bob.

The water supply to the wheel came from a reservoir on higher ground, whence it flowed through an underground cast-iron pipeline,

The Great Wheel in the Isle of Man, erected a hundred years ago, is 72 ft. 6 in. in diameter and was used to pump water out of a lead mine. Water to turn it came from a reservoir.

2-ft. bore, to the foot of a standpipe contained in a stone tower, tangential to the wheel. From the top of the tower a short flume led the water to the point of discharge into the buckets. The wheel is of the somewhat unusual "pitch backshot" type, the water flow being reversed in passing from the flume into the buckets, so that the wheel rotates towards the tower. This arrangement possessed the advantages of reducing the necessary length of flume, and of preventing the water from being blown out of the buckets in a high wind, but which was the primary motive is not now known.

For many of the foregoing particulars we are indebted to a book* recently published by a Danish engineer-antiquarian, Mr. Anders Jespersen, a member of the Newcomen Society, who has made a very detailed study of the wheel and of its mining environment, and has even gone to the length of calculating the mechanics of its operation. He appears to assume, incidentally, that the wheel revolved with a constant, or almost constant, angular velocity; it is our impression, however, that there was an appreciable "dwell" at the end of each stroke.

* *The Lady Isabella Waterwheel of the Great Laxey Mining Company, Isle of Man*, 1854-1954. Published by the author, A. Jespersen, 49 Skolebakken, Virum, Denmark. (20 Danish kronen.) Also obtainable from E. C. Kneale, Laxey, Isle of Man. (20*s*.)

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INSTITUTION OF CIVIL ENGINEERS

1954 Examination Award

A Bayliss Prize of £15 has been awarded by the Institution of Civil Engineers, Great George-street, London, S.W.1, to Mr. Arthur Mascall, South Shields, County Durham, on the result of the Institution's examinations in April, 1954. The highest marks were obtained by Mr. Peter Chung Ngar Wong, of Hong Kong, who was ineligible for the prize owing to his being above the age limit of 30 years. The Council of the Institution has granted Mr. Wong an honourable mention in lieu of the prize.

PERSONAL

SIR HAROLD ROXBEE COX, B.Sc., Ph.D., D.I.C., M.I.Mech.E., F.R.Ae.S., F.Inst.F., who until recently was Chief Scientist, Ministry of Fuel and Power, has been elected a director of The Brush Group, Ltd.

MR. H. S. TASKER, B.A., who served as honorary treasurer of the Institute of Metals, 4 Grosvenor-gardens, London, S.W.1, from 1945 to 1947, and was President from 1950 to 1951, has been elected a Fellow of the Institute of Metals, in recognition of his distinguished services to the Institute. The total number of Fellows is limited to 12.

MR. W. G. IBBERSON has been elected to be the 319th holder of the office of Master of the Cutlers' Company in Hallamshire for 1954–55, in succession to MR. R. L. WALSH. MR. R. P. PHILLIPS has been elected Senior Warden and MR. P. G. ROBERTS, M.P., Junior Warden. The Master Cutler-elect will be installed and the other officers will take up their duties on October 5.

MR. C. G. TANGYE, M.I.Mech.E., has been elected chairman of the Council of the British Internal Combustion Engine Research Association, 111–112 Buckingham-avenue, Slough, Buckinghamshire, in succession to MR. H. NORMAN G. ALLEN.

MR. G. H. ASBRIDGE, who joined the staff of Sentinel (Shrewsbury), Ltd., Shrewsbury, in September 1953, as chief designer, has now been appointed to the board of directors with responsibility for the machine-tool division.

MR. C. H. FOULKES, M.I.E.E., has been appointed by Standard Telephones & Cables Ltd., Connaught House, Aldwych, London, W.C.2, to be head of the company's valve division and location manager at Dowlish Ford Mills, Ilminster, Somerset. This division is responsible for the development and manufacture of all the firm's special valves but does not include broadcast receiver valves.

MR. W. E. JONES, M.I.E.E., who was from 1952 to early 1954, a member of the technical staff of the British Electrical and Allied Industries Research Association, Leatherhead, and, after that, was secretary of the Diesel Engine Users Association, has been appointed assistant secretary (education and technical) at the head office of the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1.

MR. NEVILLE C. WILLIAMS, A.I.E.E., A.I.Mar.E., has been appointed London manager of Mountstuart Dry Docks Ltd., and associated companies. He will work with MR. V. L. BURKE, a director.

MR. J. G. MCLEOD has been made works manager of the Willesden factory of Bowden (Engineers) Ltd., Victoria Road, Willesden Junction, London, N.W.10.

MR. A. H. WALTON who, for some years, has been in charge of the London office of Veeder-Root Ltd., makers of counting and measuring mechanisms, Kilspindie-road, Dundee, has been appointed field sales manager and will control and co-ordinate the field sales force of the company throughout the British Isles.

MR. G. G. BUCKINGHAM, M.Inst.F., has been appointed manager of the Manchester office of Babcock and Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.4, in succession to the late MR. F. W. WOODFIELD.

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BUSINESS CHANGES

CHAMBERLAIN INDUSTRIES LTD., Staffa Works, Leyton, London, E.10, have appointed DRUMMOND ASQUITH (SALES) LTD., King Edward House, New-street, Birmingham, 2, to be sole distributors, in the United Kingdom, of the production tube-bending machinery which they design and manufacture in conjunction with WALTER P. HILL INC., Detroit, Michigan, U.S.A.

Two long-established Stoke-on-Trent non-ferrous metal foundries, T. M. BIRKETT & SONS LTD., and BILLINGTON AND NEWTON LTD., have amalgamated. The company is to be known as T. M. BIRKETT, BILLINGTON & NEWTON LTD., and the headquarters will be a newly-erected administrative block at Hanley. The board of directors remains unchanged, namely, MR. A. P. WRIGHT (managing director), and MR. J. C. M. SHECKELL, MR. A. BIRKETT, MR. E. Y. BIRKETT, and MR. F. BENNET.

An associated company of HOOVER LTD., Hoover House, 211-213 Regent-street, London, W.1, has been established in New Zealand. It is HOOVER SALES AND SERVICE LTD., 105-107 Anzac-avenue, Auckland. The managing director is MR. F. W. CAVE, who has represented Hoover Ltd., in New Zealand for many years.

Obituary

MR. H. G. YATES

Senior Designer at Pametrada

We regret to record the sudden death of Mr. H. G. Yates, which occurred on Wednesday, September 15, at the early age of 46.

Henry George Yates was born on May 5, 1908, at Nenagh, County Tipperary, and was educated at the High School, Dublin, and at the Methodist College, Belfast. From 1926 to 1930 he attended Trinity College Dublin, where he obtained double first-class honours in mathematics and experimental science and was the recipient of the Fitzgerald Scholarship, the Lloyd Exhibition and a number of prizes. After acting as a lecturer in mathematics for two years, he became a student apprentice at the Willans works of the English Electric Company and in 1933 was awarded the degree of Master of Arts by Trinity College.

From 1934 to 1940 he served as assistant engineer in the Turbine Design Department of the English Electric Company at Rugby and during the latter part of this period was responsible for calculations on steam turbine plant and for other special investigations of a mathematical character. He simultaneously acted as lecturer at the Rugby Technical College in mathematics, the strength of materials and the theory of machines. In 1940 he was appointed to take charge of the research work on steam turbines at Rugby, and became the superintendent of a laboratory in which flow problems were investigated by aerodynamical methods. He was also engaged in dealing with a number of other problems connected with turbine design. He was appointed senior designer of the Parsons and Marine Engineering Turbine Research and Development Association, Wallsend-on-Tyne, in 1944, and was holding this position at the time of his death.

Mr. Yates was elected an Associate Member of the Institution of Mechanical Engineers in 1945 and was also a Fellow of the Institute of Physics and a Member of the North-East Coast Institution of Engineers and Shipbuilders.

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INTERNATIONAL I.C. ENGINE CONGRESS

Official British Participation

At a meeting held in London on September 15 of representatives of the internal-combustion engine and related industries, it was decided that the United Kingdom would, for the first time, be officially represented at future International Internal Combustion Engine Congresses.

A British National Committee was formed consisting of representatives of the following organisations: British Internal Combustion Engine Manufacturers' Association, British Internal Combustion Engine Research Association, National Association of Marine Enginebuilders, National Forgemasters' Association, Locomotive Manufacturers' Association, and Diesel Engine Users' Association, the Committee to have the power to co-opt representatives of other bodies up to a total number of twelve members.

Twenty-three firms and associations are so far supporting the arrangements for official British participation in these Congresses, and it is expected that further support will now be forthcoming from other bodies. The next session of the Congress, which will be held at the Hague in May, 1955, is concerned with the use of Diesel engines for rail traction and large Diesel engines for stationary and marine applications.

All inquiries from those wishing to attend or requiring accommodation should be addressed to the Secretary of the National Committee, c/o The British Internal Combustion Engine Manufacturers' Association, 6 Grafton-street, London, W.1, which Association has undertaken to act as the permanent secretariat of the British National Committee. Inquiries should not be sent to the organisers at the Hague or to the Permanent Secretariat in Paris.

(*Editorial comment in Weekly Survey.*)

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Letters to the Editor

ELDERLY ENGINEERS

An Association of Retired Executives

SIR, Your issue of April 21, 1950, contained an article with the above heading; and a week later Mr. C. E. R. Sams wrote to you from the City and Guilds College. As a result of your article and his letters, over 1,700 retired engineers wrote to him, and in the intervening period he has found whole-time work for about 10 per cent. of them.

Whole-time work is not necessarily the complete answer to the problem of the retired engineer; and, in the belief that a worthy object such as this should be the concern of a corporate body, a few Chartered Engineers in good standing have formed the Association of Retired Industrial Executives, for three important purposes: (1) The employment, part-time, of retired executives; (2) The supply of "predigested" information for industry; (3) The use of collective creativeness, in the form of a Guild of Inventors for youngsters with character, high intelligence, good education, and the ability to express themselves.

Such an Association would have local branches, the existence of which would provide opportunities for social occasions, lectures, discussion groups, collective approach to local industries, and the organisation of educational guidance and selection methods for the coming generation. Branches abroad could assist the export firms by market research and sales promotion; wherever English is spoken we could have a high-quality part-time expert, constantly in touch with the London headquarters. It is the intention that ARIEL (if it is formed into a limited company) should be international in character; but we defer to an excellent local association, a few months our senior, with whom we are in communication—the Association of Retired Engineers, 31 Shermanbury-road, Worthing.

Further information will gladly be sent on request, preferably accompanied by an addressed envelope, and loose stamp, or reply-coupon from readers abroad.

Yours faithfully,
G. W. WILLIAMSON.

139 Strand, London, W.C.2.
September 18, 1954.

(*Editorial comment in Weekly Survey.*)

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ELECTRICITY SUPPLY IN AUGUST

Increase Well Maintained

During August, 1954, 4,540 million kWh were sold by the British Electricity Authority to the Area Boards. This was an increase of 14·6 per cent. over the figure of August, 1953. When corrected for the weather, which was much colder than a year earlier, and the number of working days, which were more than in 1953, the increase was 9·3 per cent. The amount of electricity sent out by the Area Boards was 4,432 million kWh,while 108 million kWh were supplied direct by the Central Authority.

BRITISH ASSOCIATION MEETING

DUAL-FUEL ENGINE: TRANSISTORS

Continued from page 360

On the morning of Friday, September 3, Section G met in a single session and after a few announcements by the Recorder, Professor W. Fisher Cassie, the President, Dr. Willis Jackson, F.R.S., delivered his address entitled " Effect of New Materials on Engineering Progress," a résumé of which was given on page 325 of our issue of September 10. At its conclusion, a vote of thanks was proposed by Lord Dudley Gordon, who, in the course of his remarks, pointed out that Faraday had commenced his scientific life in a bookshop by examining books on chemistry, but he was now thought of mainly as an electrician. He was, however, also a great metallurgist, his work in this field being very much in advance of his time. Hadfield, on the other hand, was known as a research worker in metallurgy and, by his discovery of silicon steel, had made possible the full development of Faraday's original transformer. A small transformer made in 1903, he said contained about 6 lb. of silicon steel, whereas some of those illustrated by slides in the address contained as much as 60 tons of the same material, which showed the advance made as a result of this invention. The speaker then showed a small pocket knife which Hadfield had had made from alloy steel originally forged by Faraday in 1826. In conclusion, Lord Dudley Gordon said the hope the President had expressed, that he had made some contribution to what the British Association stood for, had been most brilliantly fulfilled. The vote of thanks was carried by acclamation, which was duly acknowledged by the President.

COMBUSTION PROBLEMS OF THE DUAL-FUEL ENGINE

The remainder of the morning was devoted to the reading of three papers by young engineers, the chair being occupied by Dr. Willis Jackson. The first of these papers was entitled " Some Combustion Problems of the Dual-Fuel Engine," and was by Mr. J. R. Simonson who summarised its contents; it was published on page 363 of last week's issue of ENGINEERING.

The first speaker in the discussion was Dr. A. P. Thurston, who referred to the small Diesel engines used for the propulsion of model aeroplanes and asked if the author had had any experience with them. Mr. Simonson said that he had not, but he had been experimenting with a very small Diesel engine used for the detection of methane in coal mines. The engine was run at a very high speed, being driven by an electric motor and drawing in gas containing a few per cent. of methane. If the proportion of methane increased above a certain level, the engine itself commenced to develop power and the current supply to the motor diminished. By measuring the current input it was possible to see immediately when the methane content of the gas had attained an undesirably high level.

To an inquiry by Mr. W. H. Johnson whether the dual-fuel system had been applied to any road-vehicle engines, the author replied that he thought it had only been tried with vehicles operating at sewage works. Mr. F. W. Slingerland asked whether the ignition properties of the mixtures depended to any extent on the type of oil used for the pilot ignition and whether a variation of the oil could produce better ignition. In replying, Mr. Simonson said he had only used normal light Diesel oil as it was the most satisfactory fuel for injection, but he hoped to try other fuels by introducing them into the intake manifold in addition to the methane, the object being to get the heat release throughout the whole of the charge due to compression rather than to the ignition of the injection. A typical kind of fuel to use in this way would be normal hectane and if the quantity were kept down there would be a heat release throughout the whole charge which would help the combustion of the methane.

Dr. E. A. Watson said it would appear that the most effective way of utilising the fuel was to divide it up into as many droplets as possible and he asked if any information were available relating the percentage of unburnt methane in the exhaust to the degree of distribution of the fuel droplets. In reply, the author said that tests had been made with two-hole and three-hole nozzles and the latter had shown slight improvement, but not very much.

There being no further time for discussion, Dr. Willis Jackson proposed a vote of thanks to the author and then invited Mr. A. C. Hartley, C.B.E., to take the chair for the remainder of the session.

TRANSISTORS

The next contribution to the proceedings took the form of a talk by Mr. G. King on the subject of " Transistors," given by permission of the Director of Research, Standard Telecommunication Laboratories, Limited. Mr. King pointed out that the first announcement on the subject had been made in 1948 by Bardeen and Brattain of the Bell System Laboratories, and related to an amplifying device working by controlling the motion of charge carriers in a piece of germanium. This device consisted of two " cats-whiskers," very close together, pressing on to a very small piece of germanium, the important actions taking place near the points. From a theoretical investigation, Shockley, also of the Bell Laboratories, predicted another form of amplifier, using a piece of germanium made so that there were three different zones with different properties, the important actions taking place near the junctions of these zones. The two forms were known, respectively, as point—contact and junction transistors and these names now described two large families of devices depending on somewhat different mechanisms for their working.

Mr. King said the transistor well illustrated how developments in widely separated branches of science could come together and all play an essential part in producing a new facility. In this particular field we now had a complete new science of semi-conductor engineering, and to make it, major contributions had come together from inorganic chemistry, metallurgy, crystallography, atomic physics, thermodynamics, and many others. He proceeded to explain how currents flow in transistors by movements of the planetary electrons from the shells surrounding the atomic nuclei and how, by the addition of traces of other elements, the material could be made to conduct by the movement of either positive or negative charges. To control its properties, therefore, the germanium must be in a most extraordinary state of purity for the routine starting point, with impurities less than one in 10^{10}. Mr. King indicated the chemical and metallurgical methods employed to obtain purity of this order and exhibited a small ingot produced. He also explained the operations involved in making junction transistors and the manner in which they function. He then dealt with the point-contact type, but mentioned that practically nothing had been known about what happened in these, and how to control it, until very recently. The fact that the active parts of the system in these transistors were very small, however, enabled them to work at higher frequencies than the junction type. They also gave a current gain, which is a valuable property in circuits widely used in electronic computers. Mr. King then referred to the effect of a beam of light falling on the junction of a transistor. If the beam were modulated with, say, speech, he said, the photo-transistor would provide an amplified electrical output of the speech. In conclusion, the speaker said, he thought his audience would see why transistors were held to have such high promise, but called attention to the fact that there were still certain difficulties to be overcome before they could be made cheaply and become as common as ordinary valves. Several examples of transistor-operated apparatus were effectively demonstrated during and subsequent to the talk.

SELF-EXCITED TRANSDUCTORS

The remaining paper was by Mr. D. W. Harvey and was entitled " Dynamic Behaviour of the Self-Excited Series Transductor with Direct-Current Output." As little time remained, Mr. Harvey rapidly summarised his paper, which is published on page 399 of this issue of ENGINEERING. At the conclusion, the chairman thanked the two previous speakers for their contributions and adjourned the session.

To be continued

RECRUITMENT TO THE ENGINEERING PROFESSION

A DISCUSSION BETWEEN EDUCATIONAL AND INDUSTRIAL AUTHORITIES

The two groups of authorities concerned with recruitment to the engineering profession—educational and industrial—came together for discussion at the recent British Association Meeting. The chair was taken by Mr. Ronald Gould, President of the Education Section, and the subject was introduced by Dr. Willis Jackson, F.R.S., President of the Engineering Section.

DR. WILLIS JACKSON'S REVIEW

Dr. Jackson reviewed the factors involved in the insufficient recruitment to the engineering profession to meet the present and future needs of the industry. The trained personnel of the industry, he said, fell into three main groups: professional engineers, technicians and craftsmen. In between the two main groups—the professional engineers and the craftsmen—and overlapping both of them in varying degrees, were the technicians, who had less scientific and analytical knowledge and understanding than professional engineers, and—though this was not invariably the case—less skill in manual and machine operations than the craftsmen. Some of them rose in later life to positions of senior responsibility in the industry, comparable with those occupied by some professional engineers.

Two main routes to professional engineering status had become established in this country. The most clearly defined comprised a full-time degree course at a university or major technical college followed by a period of practical training in industry, usually extending over two years. In a variant of this conventional procedure, of which he was strongly in favour, a year was spent in industry between leaving school at 17 to 19 years of age and entering the university, the second year of practical training following the degree course. This pre-university year of industrial experience had the merits that it confirmed or refuted the wisdom of the choice of engineering as a career, provided essential work-

shop practice at an age at which it was more acceptable than after graduation, and brought to the university a rather more mature individual.

The second route comprised entry to industry from school at the age of 17 to 19 years (after, preferably, taking at least part of the course leading to the General Certificate of Education at advanced level) for a four-year course of practical training, during which the student apprentice pursued a course of part-time technical education, leading successively to the Ordinary and Higher National Certificates, and to the necessary endorsements of these certificates in the chosen branch of engineering. Steps were now being taken in some areas to extract from the early years of National Certificate courses boys who appeared to possess the ability requisite for the attainment of professional status and to transfer them to sandwich-type courses comprising alternate prolonged full-time periods in industry and college. Successful candidates were at present awarded the Higher National Diploma, but it seemed likely that a new national award might be instituted for them in the near future.

Dr. Jackson concluded by raising a number of questions relating to the need to attact to a professional career in engineering more of our most able schoolboys. The accommodation and facilities available in the engineering schools of the universities and larger technical colleges, he said, had improved considerably since the war and further expansions were in progress. The number of acceptable applicants for entry to degree courses in engineering, however, was not keeping pace with this expansion, and some 300 first-year university places were unfilled during last session. Moreover, a disturbingly large proportion of those accepted—of the order of 30 per cent. in one university college—had failed to pass the first-year examination this summer; he was convinced that this was not due to an increased standard of examination and assessment.

This raised a number of crucial issues. Could the present number of engineering graduates be increased without a lowering of the standard of degree award, or without the addition of a further (intermediate) year of university study for a substantial proportion of the entrants? Was the re-introduction of an intermediate year perhaps the only effective early solution to the problem of the shortage of science teachers in the schools? In any case, was not such a transitional year essential if we were to bring into the university engineering, and indeed science, schools a proportion of the boys who, because of circumstances rather than over-riding inclination, followed the arts side of sixth-form work?

Again, would the boys who were now failing in the first-year course, possibly through difficulties of adjustment to the changed educational conditions rather than to lack of adequate ability, have had their chance of success improved by spending a year in industry, or alternatively by completing their military service, before entering the university? Or, to go a step farther, were we contriving to draw into the university engineering schools boys who would be better served by entering industry as student apprentices and following a sandwich course?

Finally, could we hope to achieve what was needed without establishing more effective means of informing schoolboys and their parents and schoolmasters of the nature, attractions and prospects of engineering as a career, and of ensuring a wider appreciation of the fact, as he saw it, that the systematic study of engineering afforded an education which was at least as valuable, as searching, and as character-building as one in either pure science or the humanities?

HEADMASTERS' DIFFICULTIES

Mr. Donald Lindsay, Headmaster of Malvern College, who opened the discussion, said he spoke as a headmaster and not as one with specialised knowledge in that field of study, and having experience only of the grammar-school world. First, he posed the question whether it was the business of the independent and maintained grammar schools to produce engineers or, indeed, to train for any particular profession or calling. Headmasters, he said, were swamped with literature and besieged by requests to lecture on a vast number of careers for boys.

On the question whether there were enough good boys to go round, he said that approximately 10 per cent. of the population were able to pursue a university career with profit. From that restricted pool every profession must draw its best boys. It was important to remember that since the war there had been a marked intensification of the struggle between the professions to attract the best boys. In that struggle the school must remain benevolently neutral. Information and advice about engineering, yes; recruitment, no.

Discussing the obstacles, apart from shortage of man-power, to increasing the number of potential engineers, he said that engineering was fortunate in that it could rely on a long tradition of greatness. It did not seem difficult to persuade boys to become engineers, for the achievements of British engineers throughout the world were sufficient in themselves to fire the enthusiasm and imagination of many boys. There would always be a number of able boys to whom the future meant engineering and nothing else; but what of the less able boys?

Many of them, and their parents, often had only the vaguest idea of what engineering involved in the way of preliminary training. The ignorance of the boys was something which could be dealt with, but it was a far sterner task to dispel parental ignorance. It was important that parents should be made aware of the educational standards required for entry into the various grades of the engineering profession.

Probably there was an equal amount of ignorance among headmasters trained in the humanities, and in a number of careers masters. The time available to read cyclostyled notes was limited, and he wondered whether a single-page document might be issued which listed the various methods of entry into the engineering profession and the educational standards required for each. The Services produced such a document, which was invaluable to headmasters.

GENERAL CERTIFICATE OF EDUCATION

Next he commented that a large number of boys in the grammar schools might be handicapped by the new organisation of the General Certificate of Education and might be deflected from engineering. In the days of the old School Certificate a hard-working boy of no very great ability could be reasonably sure of a respectable certificate before he left school. Employers accepted that certificate as an assurance that the candidate for a post had received a sound basic education. Under the new system a boy no longer had to pass in a prescribed number of subjects, but the raising of the pass standard to that of the old credit more than made up for that. Employers who were unaware of the implications of the change might reject a boy whose General Certificate of Education appeared barren, but who often was no worse intellectually than one who, a few years ealier, would have produced a School Certificate with far more subjects on it. The present General Certificate of Education regulations appeared to have been designed with the ablest boys in view, and employers seeking recruits must be ready to turn to the schools for a picture of the true worth of a boy. Time alone would bring about mutual trust and confidence among employers and headmasters. At the same time, it might be worth-while for those able to survey the whole field of industry and engineering to inquire into the working of the new Certificate at the "ordinary" level. It might be found to be a serious barrier to engineering recruitment by reason of its general acceptance as a first stage in an academic education.

Mr. H. A. Warren, Principal of the S.E. London Technical College, said that while the grammar school, university, graduate apprenticeship system of training remained as a well-worn highway leading to professional qualification in engineering, other systems of training were now numerically more significant. The 200 and more senior technical colleges of the country, through their National Certificate courses based on part-time attendance, were the means of qualification for some 4,560 students annually.

PROPOSED TECHNICAL COLLEGE AWARD

Through the Association of Technical Institutions, continued Mr. Warren, the technical colleges were examining the possibility of some form of national award—Dip. Tech. or B.Tech.—as a new qualification for that field of higher technological study which was the particular province of those colleges. The new qualification would have to bear witness to the social, cultural and philosophical qualities which were the original characteristics of a university degree. If that new high award were to connote a new combination of technical training and cultural education, it might conceivably achieve for this age of technology what the university and its degree stood for in years gone by. Such courses and their resulting award, it was proposed, would be restricted to about 15 major technical colleges the facilities of which would be expanded and improved.

We lived, he said, in an age intensely preoccupied with technics and paying great homage to the demi-god "efficiency." It was "efficient" for the student to clear his mind of all except that which subserved his immediate technical aim. He might thus concentrate on the means of living and ignore the ends of life. A remedy must be found and applied, not only in technical education, but in the philosophy and outlook of the age, which once again restored the powerful "means" of technology to the service of the liberal "ends" of human life and character. If such a change could soon be effected it would go far not only to infuse the professional technical qualification with some of the liberal values originally associated with a university degree and thus maintain the quality of entrant to the engineering profession; it would also engender that breadth of outlook and height of aspiration in our way of life which alone could preserve our technical civilisation from the real and sordid dangers of materialism.

Mr. A. E. Evans, the next speaker, who was formerly Secretary of the Association of Teachers in Technical Institutes, expressed surprise that Dr. Willis Jackson had included a modern language as one of the entrance qualifications to an engineering course, and said it was doubtful whether examination success in a modern language should be regarded as essential for that purpose, even though it might be desirable.

He asked if Dr. Jackson preferred the sandwich system, linked either with a university course or with a diploma course, to the initiation year in industry before embarking on a full-time university course. It appeared that Dr. Jackson considered that engineering education by itself was capable of giving cultural values, but that Mr. Warren did not. If there were a shortage of people about to enter engineering, then he (Mr. Evans) suggested that to insist on subjects with a quasi-cultural value was not likely to solve the problem. There was an indication that lack of knowledge of engineering drawing was a drawback to some students entering engineering courses.

Mr. Kenneth R. Evans, of the Metropolitan-Vickers Electrical Company, commented that, whereas there were vacancies in the universities, the technical colleges throughout the country were full, with queues waiting to enrol. He was glad to hear from Mr. Warren that in some secondary modern schools there was an opportunity for the boy who had not been selected for engineering training at 11-plus, without his having to transfer to another type of school halfway through his period at school. Speaking of the great change in the attitude of industry towards applying to headmasters for information about boys, he said that in a year he had received 600 to 700 replies from headmasters,

who gave complete co-operation. The School Certificate used to be helpful in giving an idea of a boy's training, but it had been replaced by something better, namely, the co-operation of the headmasters, who gave information which in the past was not sought.

WASTE OF PROFESSIONAL ENGINEERS

While there was concern about the dearth of professional engineers, Mr. Evans suggested that part of the trouble arose from the fact that in some places professional engineers were employed on work which could be done by technicians. Industry, in seeking professional engineers, was in competition with the scientific Civil Service, other Ministries, the nationalised industries and the Services. One of the most serious aspects was the failure to use to the utmost men with some technical knowledge, so that they could relieve the professional engineer of some of his work.

Dr. B. E. Lawrence, Education Officer, Essex, said he felt that engineering was unlikely to get a much higher proportion of grammar school leavers at the university level than it was getting at the moment; there were so many claims on boys reaching the sixth form that the chance of any profession getting a larger proportion in the next few years was very small. All professions would benefit a great deal if local education authorities could stop the loss from grammar schools between the ages of 15 and 18, for although many of the premature leavers would not benefit for another two years at the grammar school, perhaps 50 per cent. of those leaving prematurely would be first-rate material for the professions if they stayed on. Anything which would encourage an increase in the size of the science sixth forms was a contribution to the solution of the problem.

For 20 years Essex had been running technical schools with an entry age of 11. There again, many boys left full-time education much sooner than they should. In some places industry needed to change its outlook towards the age of recruitment for those youngsters as apprentices. In some cases boys had left school at 17 and had wished to enter engineering, but were unable to do so because of the regulations concerning apprenticeships, which had not observed the changing conditions of the past 20 years.

We had to look to the modern schools for a solution of many of our problems; the engineering industry could get a great deal more from the modern schools. If every modern school had courses taking on boys and girls to 16 and 17, a great deal of talent would be found. There were 30 to 40 such schools in Essex, but parents would not be satisfied with the modern school as an alternative to other schools until every modern school could keep its pupils beyond the statutory age.

QUALITY CONTROL

Mr. Alec Rodger, as an industrial psychologist, said he agreed with Mr. Lindsay that the proportion of able boys in the community remained fairly constant and that that proportion had to do all the high-grade jobs in the community. The implication was that we had to take the people we could get and do our best with them. In that connection he said that the Admiralty, during the war, had used quality control. They had a number of branches all wanting the best people, but experiment had shown that each branch could get roughly the proportion of high-grade people it needed, although it had also to be prepared to take others of lower quality than that to which they had been accustomed; nevertheless, they could manage. Industry, he concluded, would have to learn such lessons.

Dr. H. A. Cole asked Dr. Jackson whether the engineering profession would accept graduates in subjects other than those normally considered necessary for an engineering career. He recalled that in recruiting people for marine zoology they had found that they need not look for qualifications in zoology as the first step. Some exceptionally successful people were found who had been without qualifications in zoology. Often it was impossible for a boy to get teaching of sufficient quality in science subjects; therefore, those who were looking for first-rate boys should not confine the search to boys qualified in science. If a boy had a genuine interest in machines they could probably make him into a satsfactory engineer.

Mr. S. Price suggested that it was impossible to meet Mr. Lindsay's request that the broad requirements should be put on one sheet of paper explaining the engineering profession to the schools, for the industry was enormously varied. The Metropolitan-Vickers organisation had a long and enlightened tradition of training and education, but those who expected to find such tradition everywhere might be disappointed. It might be awkward for headmasters to receive brochures from a large number of individual firms of high repute dealing with their schemes of training; on the other hand, it might be of advantage if some national organisations, such as the Engineering Employers or the Federation of British Industries, could run a register of engineering undertakings, particularly those which provided training for boys of the sixth form at the grammar schools.

Professor A. F. Burstall, of King's College, Newcastle-on-Tyne, made the suggestion that the Federation of British Industries should commission authors to write adventure stories about engineering; also, newspapers might run a series by an engineer on "My Day." When industrialists came to King's College to speak to students they were often asked to describe a typical day in their lives; but none of them ever did. It ought to be disclosed what the great men in engineering did with their time, for thereby young boys might be attracted to the profession. When industry or engineering was portrayed on the stage the engineer or the owner was generally shown in an unfavourable position. In aeronautical engineering there was no shortage of young men. He suggested that this might be due to the way it was treated in films and novels, which made schoolboys enthusiastic about a career in aeronautics.

WOMEN ENGINEERS

With regard to the suggestion that the proportion of able people in the community was small and that engineering had to struggle for its share of them, he asked why we should struggle for only half of them. Why not try to get women into engineering, for many of the most intelligent people in the community were women? There were many jobs in engineering for which they could be employed most usefully, and he suggested that the Federation of British Industries should circularise headmistresses as well as headmasters.

The question raised by Dr. Jackson as to whether the intake into the universities could be increased without lowering the standard was not in order. The question should have been whether an increasing entry meant altering the courses, and Professor Burstall thought they must be altered. Too much emphasis was placed on the requirements of mathematics for engineering students at the universities. A great deal of creative work in engineering could be done without the large amount of mathematical knowledge which was required of the modern student.

Mr. Hall made the point that entrance requirements by the universities for engineering courses were such that it was impossible for the able student of classics or modern languages to become an engineer if he changed his mind in his second year at school.

Mr. Warren, commenting on the apparent difference between Dr. Jackson and himself on the subject of a modern language, said that whereas Dr. Jackson had been speaking of the potential university graduate coming from a grammar school, he had been referring to the secondary modern school boy entering a technical college. While he agreed that a technological course could be a good medium of cultural education, he said it might not be; it depended on the framework within which the course was set.

Dr. Willis Jackson, in replying to the discussion, emphasised the importance of informing schools about the openings available for boys in engineering, and said that a recent Easter School had been held for 100 schoolmasters in order to deal with that problem. In some schools there was a tendency to teach the wrong things. At the General Certificate of Education level there had been introduced as possible subjects the approaches to the elements of engineering science but that was quite the wrong direction in which to go. The main weakness in this country seemed to be at the technician level; we should not set about producing technicians in the way in which the United States produced them. The subject demanded greater attention both in industry and in technical institutions.

USING ARTS STUDENTS

A boy who wished to become an engineer should not concentrate over-ridingly on science at school; it was bad to try to swing the school population predominantly to science and inadequately to arts. But we were left with a dilemma. Many boys made the choice between science and the arts not because of over-riding inclination, but because of the operating circumstances —the quality of the masters, the attitude of parents, the facilities in the school and ignorance as to where education in science might lead. He asked how we were to get into science and engineering the boy who, for excellent educational reasons, followed the arts side in the sixth form at school. There was no bridge to bring such a boy over to science; that was the strongest argument for the re-introduction of the intermediate year, to serve as a bridge for such a boy. He asked, however, if many boys would wish to cross the bridge if it were provided?

Industrial concerns were seeking to do for their personnel what the Services had done, as described by Mr. Rodger. It was part and parcel of the sorting-out and up-grading of personnel in industry, seeking to select almost the lowest grade of man to perform a particular function. That underlined the technician problem and the need to improve workers' training and education.

To Dr. Cole he said the engineering industry was recruiting many physicists, chemists, metallurgists and mathematicians, but possibly insufficient attention had been given to the assimilation of arts graduates. If such graduates were to make a contribution on the technical side of industry they must, after graduation in the arts, begin to learn something of the science and engineering side, and they would need to attend technical college courses to build up that knowledge.

TELEVISION PUBLICITY

Commenting on Professor Burstall's remarks, Dr. Jackson referred to the interest created in archaeology by the television programme in which Sir Mortimer Wheeler had taken part, and suggested that a similar show by engineers might be useful. The Institution of Electrical Engineers was considering the production of a film on electrical engineering.

The standards set by the mathematician might be considered, but it would be wrong to depreciate the standard of understanding of the principles of engineering science as appropriate to professional recognition. We must produce men with adequate knowledge of engineering principles as well as of practice.

Dealing with Mr. A. E. Evans's question whether a year in industry before going to a university was preferable to a sandwich course, he said that one boy might meet the university entrance requirements and the other might not. There was merit in the first boy spending a year in practical training before going to the university. The second boy might go into industry as an apprentice and eventually take a sandwich course. There would be cases of boys who satisfied the university entrance requirements but who preferred to go into industry, and there again a sandwich course might be appropriate.

BOOK REVIEWS

Climatological Atlas of Canada. Prepared by MORLEY K. THOMAS. A joint publication of the Division of Building Research, National Research Council, and the Meteorological Division, Department of Transport, Canada. *Publications Section, Division of Building Research, National Research Council, Ottawa, Canada.* (2 dols.)

In designing buildings of almost any kind, from office blocks to power stations, consideration has to be given to the climatic conditions ruling at the site. The maximum and minimum temperatures to be expected, the extent and distribution of rainfall, the general direction and highest recorded velocity of the wind and the possibility of heavy snowfall, all may have an influence on the design. In some countries, this latter factor may not have to be taken into consideration but in Canada – in Central Quebec and Labrador – a snow load of 90 lb. per square foot on a horizontal unheated surface may be expected. These various factors will have important influences not only on the design of buildings but on the arrangement and lay-out of civil-engineering works of any type. Furthermore, it is not only the final form of any constructional work which has to be related to climate; the weather conditions ruling and the seasonal distribution of rainfall and other phenomena require consideration when the time and method of carrying out the work are decided on.

This moderately-priced and admirably-printed atlas contains 82 charts and tables which together embody information on every aspect of Canadian weather. The charts are grouped in eight sections which respectively indicate the distribution in time and place of temperature, humidity, wind, snow, rain, sunshine, seismological disturbance and permanent frost. A ninth section contains hythergraphs for various selected towns. The charts are maps of Canada on which are imposed isopleths (lines of equal measure) at intervals which show the gradual change of the factor concerned from one part of the country to another. There are 22 charts indicating temperature and its distribution throughout the year: perhaps the most useful from the point of view of constructional engineering are those indicating "design temperature" – winter design temperature being the coldest temperature which is likely to occur frequently during the average winter, and summer design temperature the hottest temperature likely to occur frequently during the average summer. The extent and distribution of snowfall and the locations of permanent frost are also clearly of importance in constructional work.

Although earthquakes are not normally rated as climatic phenomena, the inclusion of a chart relating to them in this atlas is clearly justified. The probability, or possibility, of an earthquake may be a major factor influencing the design of a large civil-engineering works and the chart indicates two areas in which major earthquake damage is possible. One is on the west coast of British Columbia and the other in the neighbourhood of Quebec.

Hythergraphs are diagrams in which abscissæ represent mean monthly precipitation and the ordinates mean monthly temperatures. The values are plotted for each month in the year and the points are joined by lines to form irregular twelve-sided figures. Barbed arrows at every third month indicate wind extent and direction. Thus, a hythergraph for any town represents in a concise way the general climatic conditions and the atlas contains hythergraphs for some 27 towns, mostly in Canada, but including Paris, London (England) and Washington, D.C. A comparison of the hythergraphs of London (England) and London (Ontario), clearly shows the equable climate of the former city for which hythergraph is a compact figure, approximating to a square, with its centre on the 50 degree F. temperature ordinate and the 2 in. precipitation abscissa. The London (Ontario) hythergraph, on the other hand, is an elongated figure showing great variation in weather conditions over the year. It extends from the 20 degree F. to the 70 degree F. ordinates; the extent of variation in rainfall is not greatly different from that of London (England), but the centre of gravity of the diagram lies approximately on the 3-in. precipitation abscissa and in January reaches the 4-in. line.

The Swansea and Mumbles Railway. By CHARLES E. LEE. *The Oakwood Press, Tanglewood, South Godstone, Surrey.* Second Edition. (7*s.* 6*d.*)

The Swansea and Mumbles Railway, constructed under an Act of Parliament of 1804, was the fifth public railway to be sanctioned in this country, and of these five it is the only independent survivor. Constructed as a goods line to connect the town of Swansea with a mineral-producing district on the east side of the Gower peninsular, the railway was at first of little significance. Three years after the line had been opened, however, a local contractor undertook to provide a regular passenger service from Swansea to Oystermouth, the original terminus. Thus, the author claims, the Swansea and Mumbles Railway can claim the distinction of having been the world's first passenger railway. Indeed this little book was originally published, in 1942, under the title of *The First Passenger Railway*.

The early history of the line is concerned mainly with financial matters, and it is not until 1877 that the first item of engineering interest – the introduction of steam locomotives – is noted. For a time, both methods of traction, steam and horse, were employed, but the horses were withdrawn in 1896. Some tentative and unsuccessful experiments were made with battery-driven electric cars in 1902, but it was not until 1929 that the line was finally electrified. In that year very large double-deck tramway vehicles, with pantagraph current collectors, were introduced, and the track was modified to allow of higher operating speeds.

From a civil engineering point of view the line is of very little interest, being laid on level ground just above high-water mark on the shore of Swansea Bay. Its method of operation, automatic signalling, and car-operated facing-point locks are unusual, and if its history is considered, the Swansea and Mumbles Railway can claim a number of distinctions. To-day it is operated as a light railway and, in spite of its tramway-type vehicles, is never referred to locally as a "tramway." The visitor will find, in fact, that the vehicles are called "trains" on all official notices, even when they are run singly, as is usual at off-peak periods. At holiday times the railway has to cope with very heavy peak loads, and for this purpose the cars can be coupled together in pairs, controlled by a single driver. Well over three million passengers are conveyed annually by the line, which is rather more than five miles long.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Corrosion Voltmeter. CAMBRIDGE INSTRUMENT CO. LTD., 13 Grosvenor-place, London, S.W.1. Voltmeter specially designed to measure the electrical potential between a buried structure and its environment. Illustrated leaflet describing principle of instrument. Corrosion is basically an electrochemical action and measurement of this potential permits an estimate to be made of the location and extent of any corrosive action taking place. To obtain absolute values of the small electric potentials involved, the voltmeter embodies the means for feeding to the circuit an equal and opposite E.M.F. to that of the corrosion voltage so that no current is taken from the structure-soil circuit; it is the applied voltage that is actually measured.

Centrifugal Pumps. HOWARD PNEUMATIC ENGINEERING CO. LTD., Fort-road, Eastbourne, Sussex. Centrifugal pumps for industrial purposes, particularly chemical and food industries. Two illustrated leaflets; emphasis on use of stainless steel for enhancing hygienic conditions.

Isotope Container. SOLUS-SCHALL, LTD., 18-22 New Cavendish-street, London, W.1. Storage and exposure container for Cobalt-60 sources up to strengths of 60 curies. Leaflet giving details of design and use.

Magnetic Sorting. SOLUS-SCHALL, LTD., 18-22 New Cavendish-street, London, W.1. Sorting and selection of ferro-magnetic material and components. Two leaflets describe sorting head—the "Magnatest Q"—and sorting bridge, respectively. The Magnatest differentiates between samples and standard pieces by variations in wave form on oscillograph. The bridge comprises conveyor belt for moving samples past head; will sort into three groups; between 1,000 and 7,000 pieces handled per hour according to size.

Cartridge Fuses. DORMAN & SMITH LTD., Manchester, 5. High-rupturing-capacity cartridge fuses for 440-volt systems. Pamphlet giving specifications and range available.

Spectrophotometer. HILGER & WATTS LTD., 98 St. Pancras-way, London, N.W.1. "Uvispek" photoelectric spectrophotometer for ultra-violet and visible ranges. Booklet describing operation, uses and range of accessories available.

Diaphragm Valves. SAUNDERS VALVE CO. LTD., Cwmbran, Newport, Monmouthshire. Full range of diaphragm valves and cocks. Handbook giving technical information on materials for handling different fluids, permissible operating pressures, etc.

Flexible Tubing. COMPOFLEX CO. LTD., 26 Grosvenor-gardens, London, S.W.1. Plastic tubes for chemical and general use; and composite tubes for heavy duty and special purposes. Leaflets for standard binder forming sections D and E of catalogue. Also general index.

Electronic Process-Controller. EVERSHED & VIGNOLES LTD., Acton-lane, Chiswick, London, W.4. Electronic controller for works processes such as flows, temperatures, pressures or levels. Three-term units for auto or hand operation. (See ENGINEERING, vol. 177, page 535, 1954.) Pamphlet giving principles, operating procedure and notes on maintenance. A second pamphlet describes various applications.

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BOOKS RECEIVED

The Gyroscope Applied. By K. I. T. RICHARDSON. *Hutchinson's Scientific and Technical Publications, Limited, Stratford-place, London, W.*1. (30*s.*)

Statistics of the Iron and Steel Industry. Part I: United Kingdom Statistics for 1953. Part II: Overseas Countries Statistics for 1952. *British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.*1. (Part I, 7*s.* 6*d.*; Part II, 15*s.*)

Vehicle Headlighting: Visibility and Glare. By A. J. HARRIS. Road Research Technical Paper No. 32. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.*)

Textbook of Illuminating Engineering (Intermediate Grade). By J. W. T. WALSH. Second edition. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London W.C.*2. (28*s.*)

Elementary Engineering Science. By ARTHUR MORLEY and EDWARD HUGHES. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.*1. (8*s.*)

Timestudy for Cost Control. By PHIL CARROLL. Third edition. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (5 dols.); and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.*4. (40*s.*)

Direct and Alternating Currents. Theory and Machinery. By E. A. LOEW assisted by F. R. BERGSETH. Fourth edition. *McGraw-Hill Book Company, Incorporated,* 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7·50 dols.); and *McGraw-Hill Publishing Company, Limited,* 95 *Farringdon-street, London, E.C.* 4. (60*s.*)

Selenium. A Short Review of its Production and Utilization with Reference to the Current Shortage. By R. ASHTON, E. G. HILL and D. NEVILLE-JONES. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (1*s.* 6*d.*)

Korrosionsschutz im Stahlbau. Veröffentlichungen des Deutschen Stahlbau-Verbandes, Heft 1/54. *Stahlbau-Verlags, G.m.b.H., Ebertplatz* 1, *Köln, Germany.* (7·50 *D.M.*)

Institute of Metals Autumn Meeting (continued from page 362)

CORROSION AND STAINING OF ALUMINIUM ALLOYS

POINTS FOR DESIGNERS

At the second technical session of the Swiss Autumn Meeting of the Institute of Metals, held in Zürich on September 8, two papers were discussed. The first was entitled "The Influence of Extrusion Direction on the Corrosion and Stress-Corrosion of Aluminium-Copper-Magnesium Alloys" and was by Mr. E. A. G. Liddiard and Miss W. A. Bell, and the second, "Staining of Clad Aluminium-Alloy Sheets During Salt-Bath Heat Treatment," was by Mr. E. C. Williams and Mr. H. J. G. Challis.

INFLUENCE OF EXTRUSION DIRECTION

The first paper related to work carried out at the Fulmer Research Institute, Stoke Poges, and was presented by Mr. Liddiard. The authors stated that stress-corrosion tests had been carried out on extrusions and rolled sheet made from the same billet of aluminium, 4 per cent. copper, 0·5 per cent. magnesium, 0·8 per cent. manganese alloy—and on sheet rolled from an extruded bar. The results had shown that the susceptibility to stress-corrosion of fully-heat-treated extrusions was strikingly dependent on the mode and direction of stressing in relation to the direction of extrusion. When stressed in bending longitudinally to the extrusion direction, extrusions were practically free from stress-corrosion. When the specimen was stressed in direct tension normal to the direction of extrusion the stress-corrosion susceptibility of extrusions was marked, and was as great as that of unclad sheet of the same composition and heat treatment. The directional effects noted above were increased by the presence of normal quantities of manganese. Stress-corrosion was not influenced by the thickness of the specimen.

Aluminium or aluminium, 1 per cent. zinc alloy coatings sprayed on to the specimens minimised or entirely suppressed stress-corrosion in sheet material. Slightly less protection was afforded by sprayed-zinc coatings and somewhat less protection by metallic-zinc paint.

DISCUSSION

Dr. U. R. Evans, F.R.S., who opened the discussion, congratulated the two sponsors of the research, the Ministry of Supply and Almin, Limited, in making the results available through the medium of the Institute. The figures contained in the paper showing the effect of directionality on the mechanical properties of certain materials should be brought to the attention of all designers. As Professor F. C. Thompson had stated on the previous day, there were many similarities in the behaviour of ferrous and non-ferrous materials when they were subjected to similar conditions. Wrought iron, for example, consisted of a series of more or less parallel layers of material. Some of these, which were fairly easily attacked by corrosive media, had been termed Q zones; others, which were relatively resistant, had been called R zones; and others again, which were very resistant, had been termed V zones. If an R or a V zone were at or near the surface of a wrought-iron bar or section the material was highly resistant to attack for long periods. At a sheared edge, however, corrosion penetrated at Q zones and, as the products of corrosion took up more space than the original material, swelling often occurred and was sometimes followed by exfoliation. Somewhat similar swelling occurred in the light alloys. These could be protected on the surface by cladding, but corrosion might occur as a result of the exposure of the basic material at sheared and similar edges. A designer might find it necessary to cut into a surface through the cladding, and this exposed the material to attack, although the cladding might confer a degree of cathodic protection to the exposed surface. It did behove a designer, however, to make special arrangements for the protection of his structures at exposed places by such means as sprayed coatings or metal-pigmented paints.

Dr. H. Sutton said that the type of alloy under discussion was not very resistant to stress corrosion. It had to be carefully watched, and, in clad form, well-tried methods of protection should be used when the cladding was removed or disturbed. Metal-pigmented paints had been mentioned, but some oil preparations, which remained "tacky" and non-brittle for long periods, had also proved very useful.

Dr. G. F. Röhner said that the authors' conclusions were important from a practical point of view. Their results confirmed work carried out by Bollenrath in Germany. This research worker had found that samples of aluminium-copper-magnesium alloys taken in the direction of extrusion lasted very much longer than those taken across. The influence of the size of the profile had also been clearly observed. Thus a profile having a small cross-section withstood exposure longer than one having a large cross-section. Again, as Mr. Liddiard and Miss Bell had found, the dependence of the corrosion on the direction of extrusion increased as the alloy additions increased. A number of other investigations on Duralumin and aluminium-zinc-magnesium alloys had been carried out, mainly in Germany. They confirmed the influence of the direction of the sample on the susceptibility to stress corrosion, particularly in the case of extrusion and forgings. With sheets, the durability was somewhat less in the case of samples taken at 90 deg. to the rolling direction than in that parallel to the rolling direction.

In a brief reply, Mr. Liddiard said that the importance of correct design must be stressed. He also felt that their conclusions were broadly justified in highly directional materials.

STAINING OF CLAD ALUMINIUM SHEETS IN SALT BATHS

The second paper, by Mr. E. C. Williams and Mr. H. J. G. Challis, of Imperial Chemical Industries, Ltd., Metals Division, Birmingham, on the "Staining of Clad Aluminium-Alloy Sheets During Salt-Bath Heat Treatment," was presented by Mr. Williams. The authors stated that the heat treatment of clad aluminium-alloy sheets in molten sodium nitrate baths was common practice. Staining of the sheets during heat treatment at 500 deg. C. occurred, however, when the free-alkali content of the salt exceeded 0·03 per cent. by weight, expressed as Na_2O. Combined alkali in the form of carbonate was not a factor in staining, and amounts up to 0·3 per cent. by weight, expressed as Na_2O, could be tolerated. Two kinds of staining were possible. So-called "instantaneous" staining occurred almost immediately on immersion at those parts of a sheet where the salt was momentarily chilled and solidified on the surface. "Immersion" staining resulted in stains which were whiter in appearance and more general in character than instantaneous stains and which occurred only at a free-alkali content exceeding 0·10 per cent. Na_2O. Instantaneous staining could occur when the free-alkali content was below 0·10 per cent. Na_2O, provided that it was greater than 0·03 per cent. Na_2O.

Electron-diffraction examination had established that instantaneous stains when first formed consisted of amorphous alumina, which was converted to various crystalline modifications on further heating at the heat-treatment temperature of 500 deg. C. Immersion stains consisted of sodium aluminate, $NaAlO_2$.

Since free alkali was the prime cause of staining, the control of this factor was essential for its prevention. Conditions which tended to accelerate the decomposition of the salt and to increase the free alkali must be avoided. It was recommended in particular that the amount of sodium nitrite addition to baths be restricted to the minimum compatible with a satisfactory life of the iron containers. Accidental contamination of baths with foreign matter, such as oil or grease, likely to accelerate decomposition should be kept to a minimum. Moreover, periods of heat treatment above 500 deg. C. should be as short as possible.

Baths that were liable to stain could be reconditioned by treatment with gaseous carbon dioxide until the free-alkali content was brought below 0·03 per cent. Na_2O. This treatment permitted the reconditioning of baths containing added nitrite.

DISCUSSION

Dr. G. F. Röhner, who opened the discussion, stated that electron-diffraction methods had been employed to examine the stains. Such methods had not yet been extensively used and he would have liked the authors to have been a little more precise in their statements regarding the type of apparatus used, the times of exposure and other relevant matters. They had also stated that while the form in which the free alkali, responsible for the staining, existed in the molten salt was unknown, it was conveniently expressed as the oxide Na_2O. He (Dr. Röhner) felt that it might be assumed that the free alkali was a mixture of Na_2O and NaOH. At the Neuhausen-am-Rheinfall Works the salts used in the salt baths had at first consisted of equal portions of sodium and of potassium nitrates; subsequently the mixture of sodium and potassium nitrate had been altered to 4 : 1. At a later date sodium chromate, and afterwards sodium bichromate, had been added and more recently sodium nitrate baths containing 10 per cent. of sodium nitrite had been used.

Mr. A. J. Field stated that at the Falkirk works of the British Aluminium Co., it had been found that oil patches on the sheets might lead to staining, otherwise they had experienced little trouble. They used 100 per cent. sodium nitrate salt baths. The next speaker, Mr. H. Taylor, thought that it was doubtful whether any advantage was gained by adding sodium nitrite to protect the iron container from corrosion. The last speaker, Mr. Christopher Smith, said that an experiment had been carried out in his works in which a series of Duralumin and aluminium-magnesium alloy sheets had been placed very close together in the salt bath and subsequently quenched. As a result no staining had occurred in some sheets, but there had been some staining in others. The matter was still under investigation.

In answer to the discussion, Mr. Williams stated that they had not felt justified in including a detailed description of the electron-diffraction method used as this followed established practice and was similar to that described in published works on the subject. In spite of what Dr. Röhner had said, the form in which the free alkali actually existed in the bath was unknown. It had been stated that 100 per cent. sodium nitrate baths had been found satisfactory and that additions of sodium nitrite were unnecessary. This matter was largely dependent on the method adopted of heating the bath. When immersion heaters were used the addition might perhaps be dispensed with, but if the bath were heated externally the addition might be necessary.

In the afternoon, members visited the works of Sulzer Bros. Ltd., J. J. Rieter & Co., Ltd., and the Swiss Locomotive and Machine Works (S.L.M.). On the following day, works and laboratories in Schaffhausen were visited.

A report of the final technical discussion of the meeting, on the constitution of titanium alloys, will be given in a forthcoming issue.

THE REDUCTION OF ALUMINIUM

A REVIEW OF IMPROVEMENTS*

By Professor Dr.-Ing. Alfred von Zeerleder†

The centenary of the first industrial production of aluminium by H. Sainte-Claire Deville (1818-81) in France seems an appropriate occasion for a retrospective review of the technical development in this field. The first successful attempts to produce metallic aluminium were made by H. C. Oersted (1777-1851) in 1825. He obtained some metallic aluminium flakes by the chemical reduction of aluminium chloride with potassium amalgam. F. Wöhler (1800-82) improved the procedure in 1827; he brought aluminium chloride vapour into contact with metallic potassium which resulted in a better control of the reaction. This method provided the basis for Sainte-Claire Deville's attempts, which, in 1854, led to the introduction of the first industrial process for the production of aluminium. The cheaper sodium was substituted for the expensive potassium, and the stable sodium aluminium chloride for the highly hygroscopic aluminium chloride. From 1855 to 1888, Sainte-Claire Deville produced in his factories in France approximately 50 tons of aluminium and the price decreased from 300 francs per kilogramme in 1859 to 66 francs per kilogramme in 1888.

ELECTROLYTIC PROCESSES

Patents for the electrolytic preparation of aluminium were applied for almost simultaneously in 1886 by P. L. T. Héroult (1863-1914) in France and C. M. Hall (1863-1914) in the United States. In the electrolytic process, a solution of alumina in molten cryolite is electrolysed at about 950 deg. C. and metallic aluminium is deposited, in the course of the electrolysis, at the cathode. No ceramic material resists the action of cryolite at 950 deg. C., and the walls of the electrolytic cell have therefore to be lined with carbon. Cryolite and carbon, for the electrode, of the requisite purity can be prepared fairly easily, but the preparation of pure alumina is quite a problem. The mineral richest in alumina is bauxite which ordinarily contains from 55 to 65 per cent. Al_2O_3, from 20 to 25 per cent. Fe_2O_3 and from 1 to 5 per cent. SiO_2. The cheapest procedure for purifying the bauxite – which is still almost exclusively used to-day – was invented in 1892 by the Austrian chemist, C. J. Bayer. It is based on the fact that alumina is dissolved quite easily by caustic soda of 45 deg. Baumé (Sp. Gr. 1·45) at 165 deg. C. and at a pressure of 6 atmospheres. Insoluble impurities such as iron, silicon and titanium may be separted by filtration; they constitute the so-called red mud.

OTHER PROCESSES

As bauxites suitable for treatment by the Bayer process are somewhat limited in their abundance, attempts have been made to try to use other, more plentiful, aluminium-bearing ores such as clay and kaolin. Various alternatives are possible. Thus, either another method of producing pure alumina or another electrolytic process could be developed, or the electrolytic process could be replaced by a thermal process followed by a refining procedure.

The only thermal method which has gained any technical importance up till now is the Pedersen process used in a plant at Höyanger, in Norway. A mixture of iron ore, coke, lime and bauxite is melted in an electric furnace and a calcium aluminate slag containing 30 to 50 per cent. of Al_2O_3 and 5 to 10 per cent. of SiO_2 is obtained with, as a by-product, iron of high quality. On account of its high silicon content, this alumina cannot be subjected to the Bayer reaction. It must be treated with sodium carbonate and this leads to the formation of insoluble calcium carbonate and sodium aluminate. The best results have been obtained with a 3-8 per cent. sodium carbonate solution containing 0·3-0·8 per cent. of caustic soda. Alumina is precipitated by CO_2 and sodium carbonate is left in solution.

ELECTROLYSIS OF ALUMINIUM SULPHIDE

Since 1890 it has been repeatedly proposed to electrolyse aluminium sulphide in place of alumina. Several advantages would result. In the first place, the consumption of the anode due to the depolarisation of the oxygen in the electrolysis of the alumina would be eliminated in a sulphide process. Secondly, the solubility of the sulphide in the electrolyte would be much higher than the solubility of alumina, which is limited, under practical conditions, to 10 per cent. In the third place, the electrolysis could be conducted at 850 deg. C., namely 100 deg. C. lower than is the case with the electrolysis of alumina. Fourthly the solvent in the electrolyte could be either cryolite or alkali chlorides, and these would make possible the substitution of firebricks for carbon as the material for the cell walls. Experience, however, has indicated that the economic preparation of a cheap aluminium sulphide of the requisite purity is not feasible. A further very serious difficulty lies in the evolution of sulphur vapours which preclude the use of open cells, and gas-tight cells are both inconvenient and expensive.

It is a striking fact that the only process to have found prolonged industrial application, besides the Héroult-Hall-Bayer method of producing aluminium is the Pedersen process, and this in special circumstances in Norway. During the late war various processes involving the use of zinc, magnesium and mercury were adopted and developed by the leading aluminium companies, mainly for the purpose of reclaiming scrap, but none of these has been employed on a large industrial scale since 1945.

Summing up the facts, the conclusion is reached that all the experiments to improve the methods for the reduction of alumina which have now been in use for 60 years have not so far led to commercial success, and the modern version of the Héroult-Hall-Bayer process is still the most economic.

* Autumn Lecture entitled "Attempts to Improve the Aluminium Reduction Process since Héroult and Hall," delivered before the Institute of Metals at Zürich, Switzerland, on Thursday, September 9, 1954. (Abridged.)

† Director of Research, S.A. pour l'Industrie de l'Aluminium, Neuhausen-am-Rheinfall, Switzerland.

FOOD ENGINEERING

TEMPERATURE AND HUMIDITY IN STORES

The work of the Food Investigation Board lies mainly in the field of biochemistry, but the treatment and storage methods which have been developed, or are under investigation, require the employment of plants which fall within the sphere of engineering. This point is confirmed by the fact that a section of the latest report of the Board* is entitled "Biological Engineering." This, however, is not to say that the report is directed principally to engineers. The purpose for which plant is used is dealt with but there are no descriptions of its detailed nature.

The section bearing the engineering title is concerned with the effects of methods of cooling, and of maintaining the temperature in a store, on the amount of evaporation from stored produce. The object of the investigation in progress is to determine the conditions which affect the loss of water, so that plant can be designed in such a way that there is a minimum loss of weight, and quality, of foods during storage. The results obtained indicate that of the total heat removed by the refrigerating plant during the cooling period, between 20 and 30 per cent. is accounted for by the latent heat of the water evaporated from the produce. In some fruit stores in which evaporation was considered to be excessive, artificial humidification was applied with fair success; loss of weight was reduced from 4·56 to 3·34 per cent., the quality and market value of the fruit being improved.

The temperature of stored fruit is of importance. Differences of temperature of as much as 4·5 deg. F. have been observed in different parts of a store, and differences of 2 to 3 deg. F. are common. This effect, over long storage periods, will result in considerable difference in quality in fruit from different parts of the same store. It is suspected that some stores have a heat leakage greater than originally estimated, thus imposing greater duty on the cooler units. This matter is clearly one of design and, possibly, of workmanship; heat-leakage tests are to be carried out on commercial stores.

As will be generally known, storage of apples at a relatively low temperature and in an atmosphere containing a controlled percentage of CO_2 is widely practised; the CO_2 is produced by the respiration of the apples. Some work is now being done on the storage of soft fruit. Plums are susceptible to low-temperature injury and intolerant of carbon dioxide gas. Investigation has, however, shown that cool storage in an atmosphere of decreased oxygen content will considerably extend storage life. Raspberries, on the other hand, are tolerant of a fairly high concentration of carbon dioxide and promising results have been obtained by pre-cooling in conjunction with storage in an atmosphere of this type. It is suggested that the Scottish crop of raspberries, which is later than the English, may be made available for the English market by transport in suitable containers. Small quantities have already been sent by road from Perth to London and arrived in good condition.

* *Report of the Food Investigation Board for the year* 1953. H.M. Stationery Office (3*s.* 6*d.* net.)

REFRIGERATION ON DEEP-SEA TRAWLERS

There are many references to refrigeration processes in the report. An important one from the point of view of the engineering industry concerns the installation of refrigerating plant on deep-sea trawlers. These vessels rarely return to port with a full catch if the distant-waters trip is prolonged; storage in crushed ice does not retard spoilage long enough to preserve the early part of the catch. An experimental refrigerating plant suitable for installation on an existing trawler is being developed. This will enable the economic value of freezing the early part of the catch to be investigated, but it is stated that full advantage of such a process is likely to be attained only when larger ships are built which can remain at sea appreciably longer and travel at more economic speeds.

MINIATURE LIQUID-FLOW METER

REMOTE DETECTION OF SPEED OF ROTATION

*By H. R. Dedow** A.M.I.MECH.E., *and R. F. J. King*†

The problem of measuring water velocities in hydraulic models of rivers and harbours, etc., presents special difficulties in that the measuring head must be very small, the response highly sensitive, and the disturbance of the stream kept to a minimum. The instrument described‡ employs miniature propellers whose angular velocity under the influence of the stream is measured without mechanical coupling by an electronic pulse counting and timing unit. The measuring head responds to velocities as low as 0·6 cm. per second, and has been subjected without damage to velocities above 3 m. per second. The complete apparatus is shown in Fig. 1.

MEASURING HEADS

Various measuring heads are illustrated in Fig. 2; in each case the helical-bladed propeller has been machined from polystyrene rod. The choice of material was based on three principal considerations, namely: low specific gravity, negligible water absorption and good electrical insulating properties. Polystyrene fulfils all these requirements and in addition it is suitable for injection moulding, should this method of manufacture prove desirable. The propellers are suspended between fine conical jewel bearings supported by a tubular Perspex mount, or alternatively, an open stainless-steel and bronze frame.

The characteristics of the four propellers illustrated in Fig. 3 are given in Table I. Propellers A and B are mounted on a stainless-steel spindle while propellers C and D are machined with an integral hollow spindle containing stainless-steel inserts at each end. Propeller D has been specially designed for use in warm water and for this purpose it is machined from unplasticised Perspex and not polystyrene.

TABLE I.—*Propeller Characteristics*

Propeller	A	B	C	D
Swept diameter	0·40 cm.	1·0 cm.	2·4 cm.	5·0 cm.
Pitch	1·11 cm.	2·36 cm.	7·5 cm.	10·8 cm.
No. of blades ..	5	5	5	5
Submerged weight (approx.)	0·008 gms.	0·012 gms.	0·02 gms.	0·5 gms.

The measuring heads are attached to the end of a fine stainless-steel tube containing a length of gold wire which protrudes from the tube at its lower end, terminating approximately 0·25 mm. from the blade tips. The wire is insulated from the tube and water except at the end face adjacent to the propeller.

PULSE COUNTING AND TIMING UNIT

The manner of detecting rotation of the propeller has been developed from a method previously employed by Dean G. B. Pegram.[1] The passage of each blade of the propeller past the gold probe produces a change in conductance between the probe and supporting frame; these changes are used to create a series of voltage pulses which can be counted and timed.

The principal elements of the pulse counting and timing unit are shown in block form on Fig. 4. The gold probe and supporting frame form one arm of a Wheatstone-bridge network which is supplied from a 10 kilocycle oscillator. The bridge is balanced when the propeller blades are clear of the probe, so that rotation produces a modulated wave with a peak as each blade passes the probe. The wave is amplified, detected and filtered to produce pulses which are further amplified before passing to a Schmitt trigger circuit. The trigger fires a chain of three dekatron counting tubes arranged in cascade so that they effectively divide the pulses by 10, 100 and 1,000. The output pulses from each dekatron together with the individual pulses pass to a selector switch the position of which determines the number of blade passages to be timed.

The selected pulses operate a Kipp relay circuit which controls the opening and closing of an electronic gate, thus the gate alternately opens and closes for periods corresponding to the interval between selected pulses. While the gate is open, signals from a 100-pulses per second source pass through the gate and a locking circuit to a second train of three dekatron counting tubes, again mounted in cascade. The complete sequence of operations is controlled by a "time-reset" key. When the key is positioned to "reset" the Kipp relay is biased to hold the gate permanently closed, the locking circuit is inoperative, and the timing dekatrons are set to zero. When the key is repositioned to "time" the bias on the Kipp relay is released, so that it opens the gate on arrival of the first selected pulse. The 100-p.p.s. signal passes through the gate to operate the dekatron timing tubes.

The gate closes on arrival of the second selected pulse and hence the dekatrons record the time period between selected pulses. In addition to closing the gate, the Kipp relay, on reversing, also applies the locking circuit which prevents further disturbance of the timing dekatrons when the gate reopens on arrival of the third, fifth, etc., selected pulses. Thus the

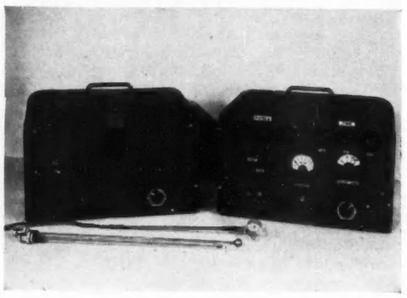

Fig. 1 The complete flow-meter apparatus. The power unit is on the left and the dekatron counter on the right.

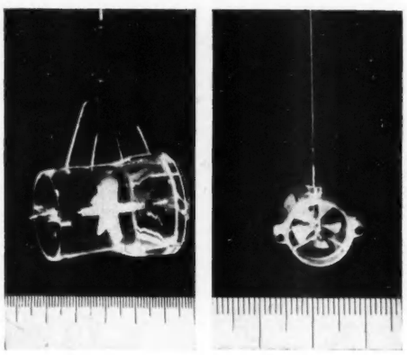

Fig. 2 Three types of gauge head shown against a millimetre scale. The propeller is not coupled mechanically to the recording apparatus and rotations are detected electronically.

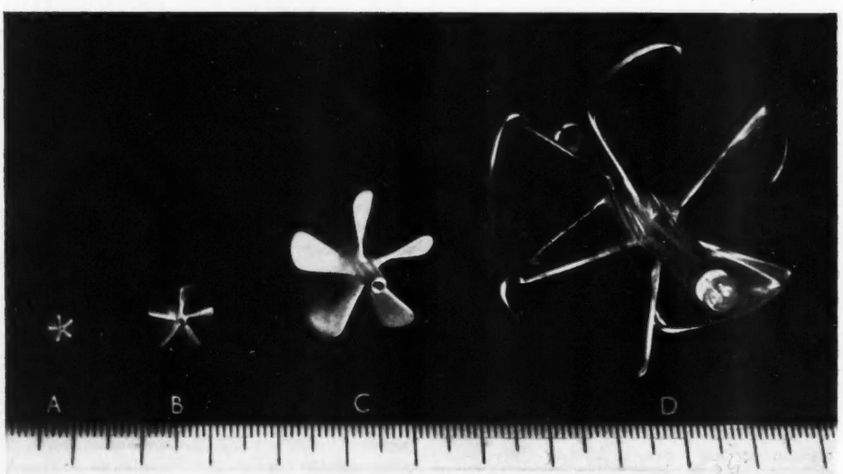

Fig. 3 Four alternative propellers. A, B and C are made of polystyrene and D, designed for use in warm water, is of unplasticised Perspex. Their dimensions are given in Table I.

* Hydraulics Research Station, Howbery Park, Wallingford.

† Now with Preece, Cardew and Rider, Consulting Engineers.

‡ The meter described was developed as part of the research programme of the Hydraulics Research Board, and this publication is by kind permission of the Director of the Hydraulics Research Station, Sir Claude Inglis, C.I.E., F.R.S.

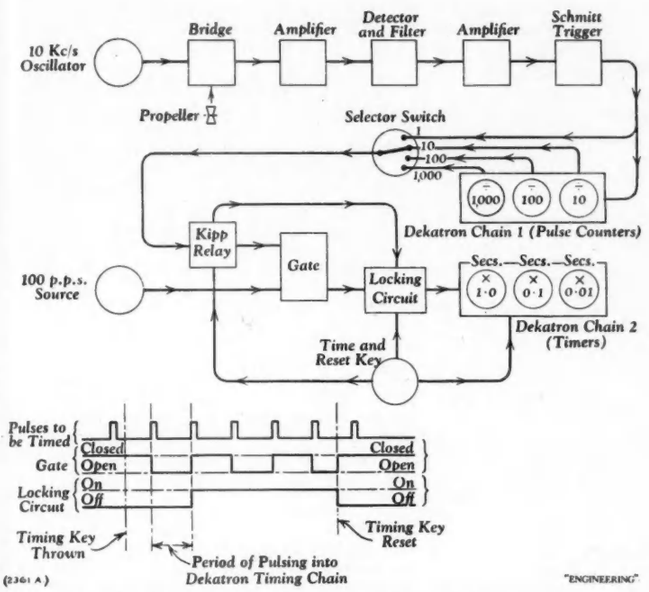

Fig. 4 Block diagram of pulse counting and timing unit.

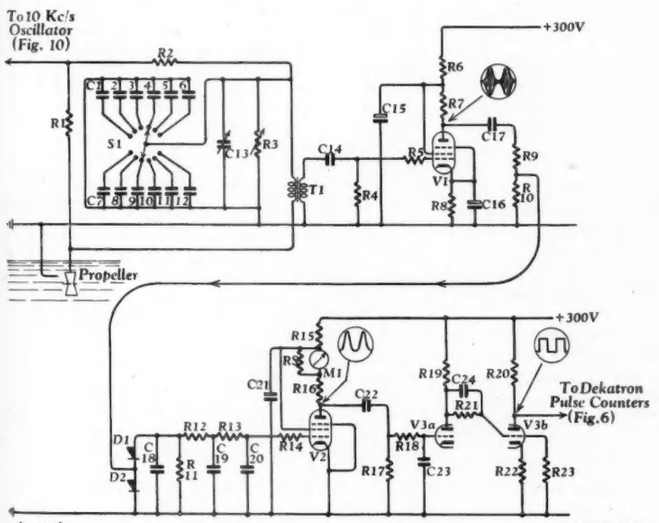

Fig. 5 Bridge and pulse-shaping circuits.

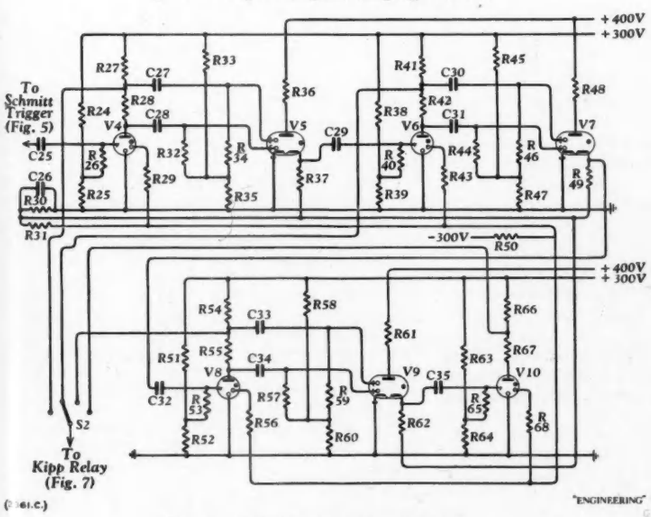

Fig. 6 Dekatron counting circuits.

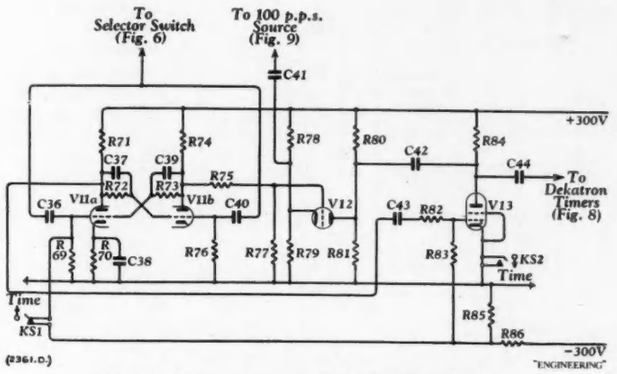

Fig. 7 Kipp relay, gate and locking circuits.

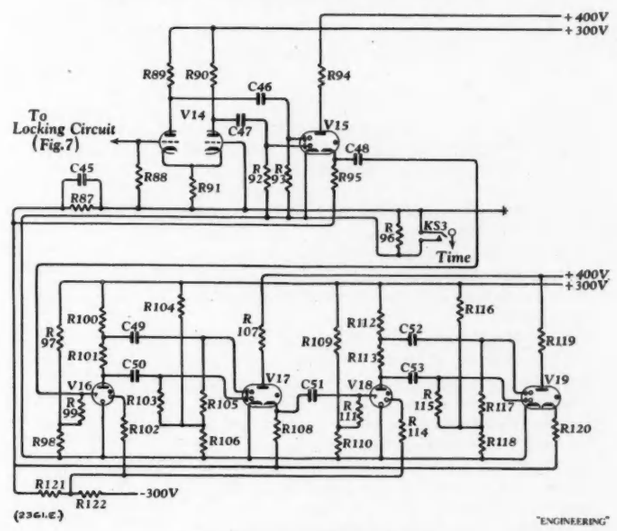

Fig. 8 Dekatron timing circuits.

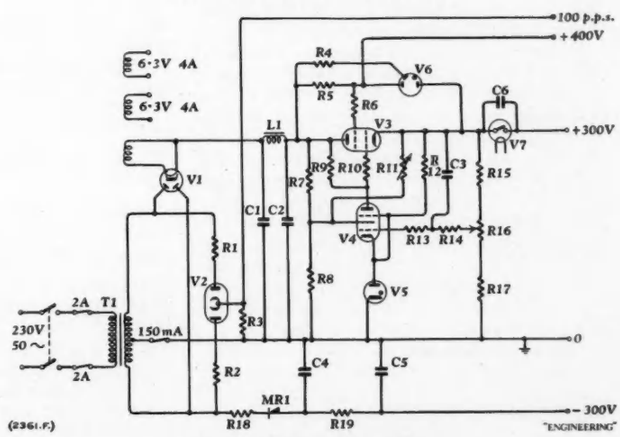

Fig. 9 Power supply circuit.

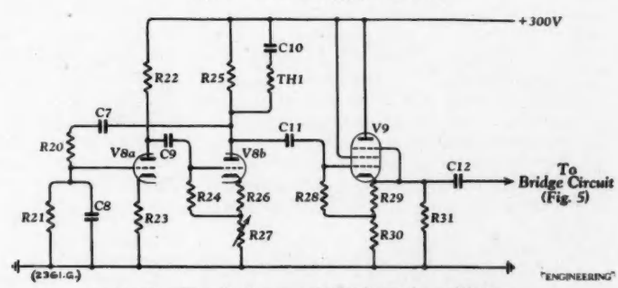

Fig. 10 Circuit diagram of 10-kilocycle oscillator.

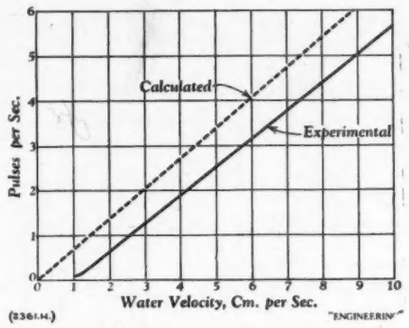

Fig. 11 Comparison of typical calibration curve with calculated values. Checks indicate that linearity continues to higher velocities.

reading remains locked until the key is repositioned to "reset" when the initial conditions are restored.

CIRCUIT DETAILS

The bridge and pulse-shaping circuits are illustrated in Fig. 5. The impedance between the propeller probe and frame together with R1, R2, R3 and C1 to C13 form a Wheatstone-bridge network which may be balanced by S1, C13 and R3. The bridge is supplied at 6 v. and 10 kilocycles from the oscillator shown in Fig. 10; at this voltage and frequency any polarisation effects at the probe are insufficient to affect the propeller performance.

The bridge output, consisting of a 10-kc. carrier wave which is modulated by the propeller, is stepped up in voltage by the isolating transformer T1, and filtered by C14 and R4 to remove spurious pick-up at mains frequency, before being amplified by V1. The germanium diodes D1 and D2 rectify the signal, which, after removal of the carrier frequency, is further amplified by V2. The grid bias for V2 is obtained by setting the bridge slightly off balance so that modulation is not 100 per cent. The meter M1 in the anode circuit of this valve shows maximum deflection when the bridge is completely balanced, the necessary bias being obtained by off-setting R3 to reduce this reading by approximately 10 per cent. Valve V3 and its associated components form the Schmitt trigger rectangular output of which drives the dekatron counting chain shown in Fig. 6. The dekatron circuits are essentially those recommended by the manufacturer.[2] The cold-cathode trigger tetrodes V4, V6, V8 and V10 fire respectively for each pulse, every 10th pulse, every 100th pulse and every 1,000th pulse, and their resulting output signals are taken to the selector switch S2; these output pulses are negative in sign.

The Kipp relay, gate and locking circuits are illustrated in Fig. 7. When the timing key is positioned to "reset" the grid of V11a is connected through KS1 to a negative bias greater than cut-off; thus the conducting path is through V11b. The amplitude of the selected pulses arriving at both grids is insufficient to disturb this state, so that the potentials at the anode of V11b and the directly coupled grid of V12 remain steady at reduced values. Both the cathode and anode of V12 are held at a steady potential of 150 volts by R78, R79, R80 and R81. Pulses of 100 p.p.s. frequency are superimposed on the cathode potential but do not appear in the anode circuit since the valve is cut-off. The locking thyratron V13 also does not conduct as KS2 is open.

Consider the timing key to be repositioned to "time." Contact KS1 opens removing the bias from V11a; the first selected pulse to arrive at the grids now switches the conducting path from V11b to V11a, causing the potential at the anode of V11b to rise sharply, and with it, the grid of V12. This valve now conducts so that the 100 p.p.s. signal is reproduced in its anode circuit, and passes through C42 and C44 to the timing dekatron chain. The second selected pulse switches V11 back to its initial condition, returning V12 to cut-off. Thus the timing dekatron chain has been driven for the interval between selected pulses. When V11 returns to its initial conducting state a positive pulse from the anode of V11a fires V13 which remains conducting, effectively short circuiting the output of V12. Hence, when the gate reopens on arrival of the third, fifth, etc., selected pulses, the timing signal does not disturb the recorded time for which the gate was first opened.

The dekatron timing circuits shown in Fig. 8 are similar to the pulse counting circuits of Fig. 6, but the first dekatron tube is driven from V14 which produces pairs of rectangular pulses. The potential difference across R96 when KS3 is open returns the dekatrons to zero.

POWER SUPPLIES AND TACHOMETER

The power-supply circuits shown in Fig. 9 are of conventional design and require little comment. The + 400-volts supply is stabilised up to approximately 5 mA and the + 300 volts supply up to approximately 65 mA. Two heater supplies are provided, one being reserved for valves whose cathode is above earth potential. Valve V2 supplies the 100 p.p.s. timing signal by rectification of the mains frequency.

The power unit also houses the 10 kc. oscillator illustrated in Fig. 10. Valve V8 and its associated circuits oscillate at approximately 10 kc., the frequency being determined by C7, C8, R20 and R21; thermistor TH1 stabilises the amplitude of oscillation. The cathode follower V9 acts as a buffer stage to prevent the bridge loading the oscillator.

In addition to the pulse counting and timing unit described in the foregoing paragraphs an electrical tachometer has been developed which indicates the instantaneous angular velocity of the propeller as a meter deflection. The readings are provided on four linear scales and the unit incorporates facilities for obtaining a continuous plot on a recording ammeter. Details of this unit will be published shortly.

CALIBRATION AND PERFORMANCE

At present, experience with the meter is limited, and calibration has been carried out only at low velocities; therefore firm conclusions on performance cannot be drawn at this stage. However a typical calibration curve is shown in Fig. 11, and a rough check against a Pitot tube indicates that the linearity continues to higher velocities. The relative merits of tubular and frame mounting have yet to be fully investigated, but it may be said that, whereas response in the frame mounting follows an approximate cosine law when the propeller axis is rotated relative to a steady stream, the response of the tubular mounting actually increases for small angular displacements before falling away at the larger displacements.

Some trouble has been experienced during measurement of velocities in open-air channels owing to fine fibrous hairs adhering to the propeller pivots.

REFERENCES

[1] Brehon, B. Somervell, *Trans.A.Soc.C.E.*, vol. 95, p. 800 (1931).
[2] Ericsson Telephones Limited, 22, Lincoln's Inn Fields, London, W.C.2.

1955 CONFERENCE ON COMBUSTION

Joint I.Mech.E. and A.S.M.E. Meetings

Arrangements have been made by the Council of the Institution of Mechanical Engineers to hold a conference on combustion, in conjunction with the American Society of Mechanical Engineers. The main meeting will take place at the Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A., on Wednesday, Thursday and Friday, June 15, 16 and 17, 1955. This will be followed by another meeting, in London, on Tuesday, Wednesday and Thursday, October 25, 26 and 27, 1955, at which the same papers will be discussed.

The objects of the conference are to link theory and practice in the field of combustion, by presenting to practical engineers in the United States, Britain and elsewhere the results of theoretical work, and to provide opportunities for engineers from these countries to discuss practical applications of the theory of the subject.

The conference, both at Cambridge, Massachusetts, and in London, will be arranged in six sections, five of which will be devoted, respectively, to general lectures on combustion, combustion in boilers, combustion in furnaces, combustion in internal-combustion engines, and combustion in gas turbines. The concluding section will be used for dealing with the more important matters arising from discussions during the earlier sections.

Altogether, some 40 papers will be presented, and advance copies of them will be available prior to the date of the American meeting. The papers will be presented for discussion by reporters, each of whom will deal with the papers relating to a particular section. The *Proceedings* of the conference, comprising the papers, the reporters' introductions, discussions, written communications, and the authors' replies, will be published in book form as soon as possible after the conference. Details as to the availability of the *Proceedings* will be made known at a later date.

Further particulars may be obtained from the secretary of the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1.

* * *

INSTITUTE OF METALS

Special London Meeting

For the benefit of members of the Institute of Metals who were unable to take part in its 1954 autumn meeting in Switzerland, a special general meeting has been arranged and will be held at the Institute's headquarters, 4 Grosvenor-gardens, London, S.W.1, on Thursday and Friday, November 25 and 26, 1954.

At the opening session, on November 25, at 2.30 p.m., there will be a discussion on "The Constitution of Titanium Alloys," based on a series of eight papers already published in the Institute's *Journal*.

On November 26, there will be a morning session at 10 a.m. at which a discussion on "Preferred Orientation," based on three papers in the Institute's *Journal*, will take place. The concluding session, at 2.30 p.m., will be devoted to a discussion on "Corrosion and Staining of Aluminium Alloys," also based on papers in the *Journal*.

Non-members of the Institute will be welcome at this meeting and tickets will not be required.

* * *

We have been informed that the figures for the tensile and shear strength of Deborine are reversed in the table given on page 252 *ante*. The tensile strength should be 15,000 lb. per square inch and the shear strength 4·25-5·0 tons per square inch.

SELF-EXCITED SERIES TRANSDUCTORS*

PERFORMANCE UNDER VARIOUS CIRCUIT CONDITIONS

By D. W. Harvey

A transductor is a device in which saturable cores control the average value of an alternating-supply current. The transductor is usually connected in series with the load, and control is effected by a direct-current signal which determines the point on the alternating-current cycle at which the cores saturate. When the cores saturate, the impedance of the transductor becomes very low so that nearly all the supply voltage is transferred to the load. By varying the value of the signal current the point of saturation, and hence the mean value of the load current per half cycle, is altered.

In servo work, the block diagram technique of synthesis is widely employed, and it is necessary to know the transfer function of components used in the design. For a transductor, it is necessary to know the relationship between the load-current output and the input signal, which is the control voltage. Since this relationship depends on the nature of the load, the transfer function for each load condition is examined separately.

The transfer functions are established in terms of circuit parameters, so that when the results are applied to servo-synthesis, the responses may be predicted without the necessity of carrying out tests. The treatment commences with a short description of the experimental techniques employed, and then single-sided transductors with resistive and inductive-resistive loads are considered, together with the effect of capacitor smoothing. The treatment is then extended to push-pull circuit arrangements of the series-summing type and to amplifiers of more than one stage, with this kind of inter-stage coupling.

EXPERIMENTAL TECHNIQUE

The harmonic response method of testing was adopted to obtain the experimental data, because of convenience of measurement, and because of the ease of interpretation. The apparatus was designed to be relatively simple, so as to reduce errors to a minimum, and null methods of measurement were used where possible. For descriptive purposes the equipment may be conveniently considered in two parts; one consisting of the signal source, and the other comprising the measuring and detecting device. The signal generator and its associated low output impedance amplifier were based on a design developed and described by Burns and Cooper.[1] The operation depends upon the mechanical modulation at the signal frequency of a 2 kc/s carrier in two Magslips (or Synchro units). A phase difference between the envelope waves of the two units is introduced by an adjustable mechanical phase shift between the rotor couplings of the machines. By feeding these two waves through de-modulators and filters, two low-frequency sinusoidal waves of known phase difference are obtained from the arrangement. So as not to impose a load on the de-modulators, a low output-impedance amplifier is incorporated in the circuit, which is then capable of supplying signals for transductor control.

In the detecting and measuring equipment, phase balance is obtained by using a cathode-ray oscilloscope to detect the rotor setting giving a straight-line Lissajous's figure on the trace. The X-plate amplifier of the oscilloscope is connected to the reference signal, and the Y-plate amplifier is connected to the input of the device under test, whence a balance point is obtained. Then by reconnecting the Y amplifier to the output of the test object, the phase angle through which the Magslip rotor is turned to obtain a new balance, is equal to the phase shift through the test amplifier at that particular signal frequency.

To measure the relative signal gain or attenuation in the amplifier under test, a similar comparative technique is adopted. The Y amplifier of the oscilloscope is connected to the input of the test object and the frequency-amplitude response over the test frequency range is taken. Then by reconnecting to the output of the test object and plotting a similar curve, the amplitude response can be calculated. For any given frequency, the attenuation of the device under test is equal to the attenuation of the output divided by the attenuation of the input. For greater accuracy, the amplitude is measured by varying a calibrated attenuator so that the trace on the oscilloscope has a constant amplitude.

With transductors under examination, it is necessary to insert a filter between the " testing point " and the input to the oscilloscope so that most of the transductor carrier is removed. As the filter is in circuit for both the input and output readings, any attenuation introduced by this component is subsequently eliminated when the ratios of output and input attenuations are taken. This statement is only true if the filter conditions remain constant; so to achieve this a cathode follower is incorporated in the circuit in front of the filter. A block diagram of the circuit arrangement is shown in Fig. 1.

Particulars of the transductors used are given in an Appendix to this paper, and the following notation is employed in the treatment.

Notation.

Rc	Total resistance of control circuit—ohms.
r	Resistance of main windings plus forward rectifier resistance—ohms.
R_L	Resistance of load—ohms.
Rs	Resistance of each summing resistor—ohms.
Lc	Inductance of control windings for single-sided transductor—henries.
Lc'	Inductance of control windings for push-pull pair of transductors—henries.
f	Supply frequency—c/s.
Ic	Control current—mA.
Ib	Bias current—mA.
I_L	Load current—mA.
Ic'	Capacitor current—mA.
Vc	Control voltage—volts.
Vav	Average output voltage (total)—volts.
A	Attenuation.
ϕ	Phase shift—degrees.
Nc	Number of control turns.
Na	Number of main turns.
T	Time constant—secs.
α	Angle of core saturation—radians.
ss	Single sided.
pp	Push-pull.
ω	Angular frequency of signal, radians per sec.
ω'	Angular frequency of supply, radians per sec.

SINGLE-SIDED TRANSDUCTORS

Rectifier-Fed Resistive Load.—The series transductor connection with resistive load has been examined by many authors from the theoretical as well as from the experimental viewpoint. The load contains no energy store, so in an investigation of the transductor dynamics the rectifier can be replaced by its equivalent resistance and the time constant is of the same form as that for a simple LR circuit. The examination of the harmonic response was carried out by the measurement of the phase angle between the input and output signals. Since the transfer function is of the form

$$\frac{I}{Ec} = \frac{1}{R + j\omega L}, \quad . \quad . \quad (1)$$

the phase lag is $\tan^{-1}\frac{\omega L}{R}$, and the time constant is given by

$$T = \frac{L}{R} = \frac{\tan\phi}{\omega}. \quad . \quad . \quad (2)$$

In all tests the value of $\frac{\tan\phi}{\omega}$ for various values of ω was found to be constant, other conditions being unchanged, thus confirming that the transductor was behaving as a simple inductive-resistive (LR) circuit.

Analytically it has been shown[2,3] that the time constant of a series transductor with a rectifier-fed resistive load may be expressed as

$$T = \frac{1}{4fNa}\frac{Nc}{}\left(\frac{\Delta I_L}{\Delta Ic}\frac{R_L + r}{Rc}\right). \quad . \quad (3)$$

This may be rewritten as

$$T = \frac{Lc}{Rc}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where

$$Lc = \frac{1}{4f}\frac{Nc}{Na}\left(\frac{\Delta I_L}{\Delta Ic}(R_L + r)\right). \quad . \quad (5)$$

One verified feature of this expression is that the time constant is independent of the value of the load resistance. To further check this expression tests were made in which the value of Rc was varied. The results could be represented by the straight line for the single-sided transductor in Fig. 2. This line does not pass through the origin as it would do if equation (3) were completely true, but the deviation represents only one half-cycle of the 400 c/s transductor supply frequency. This effect has been observed previously and it is generally recognised that transductors have a small auxiliary time constant associated with the main windings or self-excitation windings. This auxiliary time constant is in part caused by the delay between Ic and I_L, since the effect of Ic can only be imposed on I_L

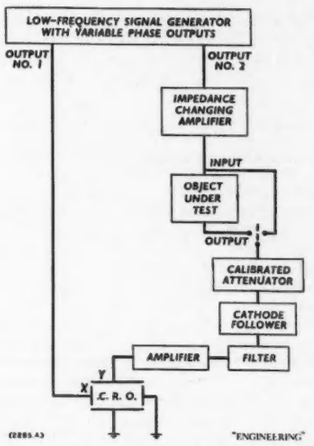

Fig. 1 Block diagram of testing circuit.

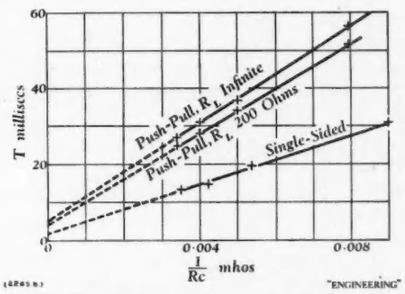

Fig. 2 Variation of time constant with conductance of control circuit for resistive loads.

* Paper entitled "Dynamic Behaviour of the Self-Excited Series Transductor ' read before Section G of the British Association at Oxford on Friday, September 3, 1954. Abridged.

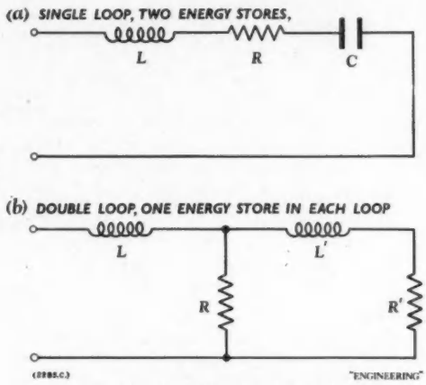

Fig. 3 Circuits with second-order transfer functions.

twice a cycle. Thus there can be a delay of up to half a cycle, whereas in the simple exponential equation, Ic and I_L are assumed to be instantaneous quantities. Detailed examination of this point is outside the scope of this paper. In succeeding sections the auxiliary time constant is neglected since it is small, and is not readily expressed in terms of circuit parameters.

Rectifier-Fed Inductive-Resistive Load.—Approached from a theoretical viewpoint, the inductive-resistive load condition may be expected to have a transfer function of the form

$$\frac{I_L}{Ec} = \frac{K}{Rc} \cdot \frac{1}{1+j\omega Tc} \cdot \frac{1}{1+j\omega T_2}, \quad (6)$$

where Tc is the time constant of the control circuit, and T_2 is the time constant of the load circuit. This equation might also be expected from the switch concept of transductor action, as before saturation only the control circuit has any effect, and after saturation only the load circuit has any effect, Lc then being zero, so that there can be no interaction between the two circuits. However, experiments showed that equation (6) was not adequate as a representation of the transfer function of a self-excited series transductor with this type of load.

The initial experiments indicated that the relationship between the load current and the control voltage was a second-order equation. Then, in general terms,

$$\frac{I_L}{Ec} = \frac{K}{p^2 + bp + c}, \quad . \quad . \quad (7)$$

or

$$\frac{I_L}{Ec} = \frac{K}{R} \cdot \frac{1}{\left(\frac{j\omega}{c}\right)^2 + \frac{bj\omega}{c} + 1}. \quad . \quad (8)$$

All that is necessary to determine the relationship is for the expressions for K, *b*, *c*, and R to be determined. To obtain systematic experimental evidence, a series of harmonic response tests was carried out, in which for simplicity the value of Rc was the variable parameter. The transductor had 100 per cent. self-excitation, the inductive-resistive load was supplied through a separate bridge rectifier, and the transductor was biased so that it was operating about the mid-point of the linear part of its characteristic.

In Table I, experimental values of $\frac{\sqrt{c}}{2\pi}$ obtained from the plotted curves are compared with calculated values deduced from Rc, Lc, $(R_L + r)$, and L. The tests were made for a load of induc-

TABLE I.—*Comparison of Experimental and Theoretical Values for* $\frac{\sqrt{c}}{2\pi}$ *for Varying Rc.*

Rc total, ohms ..	43	111	186	261	481
Expt. rel. amp. ..	0·37	0·41	0·41	0·41	0·41
$\frac{\sqrt{c}}{2\pi}$ c/s	3·9	5·7	7·5	8·8	11·5
$\frac{1}{2\pi}\sqrt{\frac{Rc(R_L+r)}{Lc\,L}}$ c/s	3·8	6·1	7·9	9·4	12·6

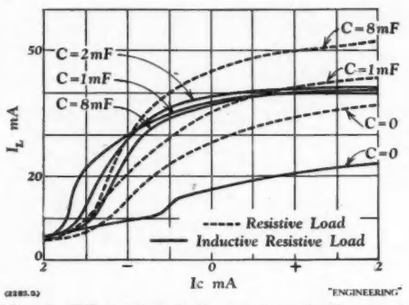

Fig. 4 Effect of control current on load current for different values of smoothing capacitor.

tance 10·9 henries and 330 ohms resistance (plus 132 ohms for the rectifier forward resistance). The control circuit inductance was taken as 3·2 henries, the same value as that calculated for the purely resistive load. In other words, the value of $\frac{\Delta Vav}{\Delta Ic}$ was taken to be the same, although with an inductive-resistive load, the current gain was less than with a purely resistive load.

In all tests the high frequency end of the curves tended to be asymptotic to a 40 db/decade line drawn through the point on the zero db/decade line corresponding to the frequency at which the phase shift was 90 deg., as would be expected from the transfer function of equation (8). From Table I it will be seen that there is good agreement between the values for $\frac{\sqrt{c}}{2\pi}$ obtained from the experimental curves, and the values calculated from the corresponding values of Rc, R_L, *r*, Lc, and L.

Considering now the values obtained experimentally for the relative amplitude at $\omega = \sqrt{c}$, (i.e., ω_0), it will be seen that these values are approximately constant. Substituting in the requisite equation, then $\frac{\sqrt{c}}{b}$ = constant.

The original equation therefore becomes

$$\frac{I_L}{Ec} = \frac{K}{Rc} \cdot \frac{1}{\left(\frac{j\omega}{\omega_0}\right)^2 + 2\xi j\left(\frac{\omega}{\omega_0}\right) + 1}, \quad (9)$$

where

$$\omega_0 = \sqrt{\frac{Rc(R_L + r)}{Lc\,L}}, \quad . \quad (10)$$

ξ is a constant, and K is the dimensionless gain constant $\frac{\Delta I_L}{\Delta Ic}$. The gain constant of course depends on the load, but is independent of any variation in the control circuit resistance.

In this type of quadratic expression, ξ is normally called the damping factor. For $\xi < 1$, the system is underdamped, for $\xi > 1$, overdamped, while for $\xi = 1$, it is critically damped. For the transductor, $\xi = 1{\cdot}2$, so that the system was overdamped.

To provide further examination of equations (8) and (9), the frequency response measurements were repeated for other values of the load resistance and inductance. It was again found that the equations held, and moreover, the damping factor was unchanged, namely 1·2.

To increase the range of the work, further response curves were plotted for different degrees of self-excitation on the transductor. Although the response was of the same form with a corresponding determination of *c*, i.e. $\frac{Rc(R_L + r)}{Lc\,L}$, it was found that the value of ξ depended on the degree of self-excitation. This tendency is shown in Table II.

TABLE II.—*Variation of Damping Factor with Degree of Self-Excitation.*

Percentage self-excitation	95	100	105
ξ Damping factor	1·0	1·2	1·7

As Lc is a function of the gain of the transductor, the value of $\sqrt{\frac{Rc(R_L + r)}{Lc\,L}}$, i.e., the frequency to give a 90 deg. phase shift, would naturally change with the degree of self-excitation.

The type of transfer function given by equation (9) is typical of the response obtained from a system containing a single loop with two "non-additive" energy stores, as opposed to a double system with an energy store in each loop, as for equation (6). An example of the former is a circuit with a resistance, inductance, and a capacitance in series, as in Fig. 3(*a*), while a mechanical equivalent is an error-actuated positional servo with non-rigid coupling and inertia in the output shaft, there being overall position feedback. Both these examples are discussed fully in standard text-books on servo-mechanism theory.

With Capacitance on Output Side of Load Rectifier.—The effect of the capacitor across the load rectifier output to some extent depends upon the type of load, so that it is necessary to consider each class of load independently. With a resistive load the addition of a smoothing capacitor causes a considerable change in the load current, and a typical set of curves plotting I_L against Ic for various values of capacitor is shown in Fig. 4. The immediately obvious point is that the gradient $\frac{\Delta I_L}{\Delta Ic}$, as well as the actual current, is greater, but that for the larger values of capacitance the characteristic tends to lose its linearity. A simple explanation of these phenomena is that the effect of the capacitor is merely to reduce the apparent value of R_L, because of the pulse nature of the voltage. As during the time when the transductor cores are unsaturated, the instantaneous load current, caused by the capacitance discharging, varies exponentially, the percentage increase in load current caused by the addition of the capacitor would depend upon the length of time the cores are unsaturated. Thus the $\frac{\Delta I_L}{\Delta Ic}$ characteristic would progressively tend to lose its linearity for increase in load capacitance.

From this consideration it may be expected that capacitance across the load has no effect on the time constant, since it has already been shown that the time constant is independent of the value of the load resistance. This contention was borne out by experimental evidence since, for constant bias conditions, the time constant was found to be independent of the value of C as well as being independent of the value of the load resistance. Thus the capacitor has the effect of increasing the ratio of gain to time-constant, although this may be at the expense of linearity for larger values of capacitance.

With an inductive-resistive load, a much improved static characteristic was obtained. Not only was the gradient of the linear part of the $\frac{I_L}{Ic}$ curve greater, but in addition it was increased in length, as shown in Fig. 4. Above a certain minimum capacitance the size of the capacitor has negligible effect on the current gradient.

On examination of the voltage waveform across the output of the load rectifier with an oscilloscope, the waveforms in Fig. 5 were observed. (In Fig. 5, β is the angle at which the load current becomes greater than the transductor current.) As there is current flowing in the load during the horizontal portion of the trace with a 1-mf. capacitor across the load, then the rectifier must be conducting current round the loop formed by both halves of the load rectifier bridge, in parallel with each other, and the load. But this value of capacitance, from Fig. 4, is too small to give full improvement of the characteristic, and a suitable criterion for the minimum value of smoothing capacitance appears to be that for which at no time does the load rectifier conduct with the two halves in parallel.

For servo work it is usually necessary to bias the transductor so that it is operating about the mid-point of its linear range. Now this corresponds, as will be seen from Fig. 4, to approxi-

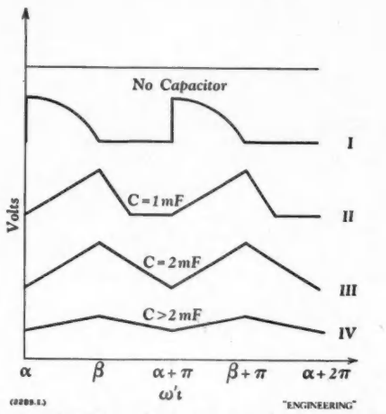

Fig. 5 Waveform of voltage across output of load rectifier for various values of capacitance.

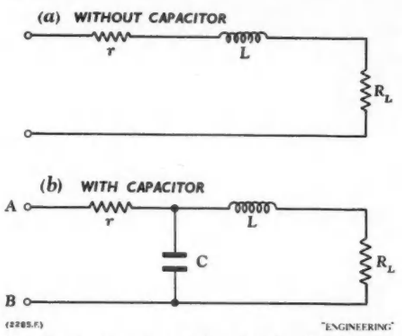

Fig. 6 Equivalent circuits of inductive-resistive load.

mately half maximum load current. The maximum load current flows when the transductor cores are saturated for the whole cycle so, as an approximation, it is reasonable to assume that under normal operating conditions, the cores are unsaturated for half the time. It can be shown analytically that the value of capacitor necessary to obtain the minimum condition stated above is given by

$$2\,Co\,R_L = t, \quad . \quad . \quad (11)$$

where t is the time for discharge per half cycle of the supply. But with the above assumption, $t = \frac{1}{4f}$, so that

$$2\,Co\,R_L = \frac{1}{4f}. \quad . \quad . \quad (12)$$

Confirmation of equation (12) was obtained by varying the value of C and observing on an oscilloscope the values that gave the waveform nearest to the required condition, for various loads. The results are shown in Table III, where it is seen that the experimentally determined values of 2 Co RL (about 6×10^{-4} sec.) correspond closely to the time for a quarter cycle of the 400 c/s supply frequency.

TABLE III.—*Determination of 2 Co RL for Varying RL.*

RL ohms.	150	200	220	250	300	350	400
Co for L = 5·45 h. *m* F.	1·8	1·5	—	1·2	1·0	0·9	0·8
Co for L = 10·9 h. *m* F.	—	—	1·3	1·2	1·0	0·9	0·8
2Co RL 10^{-4} sec. . .	5·4	6·0	5·8	6·0	6·0	6·2	6·4

Further, these results show that the value of Co is independent of the value of load inductance L, which is also to be expected from the analytical examination. The only limit assumed in the analysis is that the time constant of the load is large when compared with the time of a quarter cycle of the supply frequency.

If the transductor is conducting for half of the total time, then, during the conducting period, provided that the load current is constant for the whole cycle,

$$\int_0^{\tau} I_L\,dt = \int_0^{\tau} Ic'\,dt. \quad . \quad (13)$$

This is true as during the non-conducting period the load current is provided by the capacitor. The transductor supply current is the sum of these two components, so that when equation (13) applies the time constant of the total effective load of the transductor may be approximately represented by $\frac{L}{2R_L + r}$. Thus, from equation (9),

$$\frac{I_L}{Ec} = \frac{K}{Rc} \frac{1}{\left(\frac{j\omega}{\omega_0}\right)^2 + 2\xi j\left(\frac{\omega}{\omega_0}\right) + 1},$$

where now

$$\omega_0 = \sqrt{\frac{Rc\,(2R_L + r)}{Lc\,L}}. \quad . \quad . \quad (14)$$

This change of ω_0 by the addition of a smoothing capacitor is because of the pulse nature of the supply voltage, and as such may be termed a carrier effect. Further to this effect, the transfer function, for the signal, of the load circuit is changed by the addition of the capacitor. Without a capacitor, the output circuit is equivalent to Fig. 6 (*a*), and has the transfer function

$$\frac{I_L}{Vav} = \frac{1}{R_L + r + j\omega L}, \quad . \quad (15)$$

while with a capacitor the circuit is as in Fig. 6(*b*), the transfer function then being

$$\frac{I_L}{Vav} = \frac{1}{(R_L + r) - r\omega^2 LC + j\omega(L + CrR_L)}. \quad . \quad . \quad . \quad (16)$$

For simplicity assume that the overall transfer function of the transductor, allowing for the carrier effect, is

$$\frac{I_L}{Ec} = \frac{K}{Rc} \frac{1}{1 + j\omega\frac{Lc}{Rc}} \frac{1}{1 + j\omega\frac{L}{2R_L + r}}, \quad . \quad . \quad . \quad (17)$$

where the first part of the function refers to the time constant of the control circuit, and the second part to that for the load circuit. This assumes that the two time constants are independent of one another, whereas in fact it has been shown that they are related as in equation (9). This assumption is necessary because it is difficult to incorporate in equation (9) the complex expression for the response of the signal resulting from the addition of a capacitor. Now allowing for the effect of the change of the load circuit on the signal, the overall transfer function becomes

$$\frac{I_L}{Ec} = \frac{K}{Rc} \frac{1}{1 + j\omega\frac{Lc}{Rc}} \frac{1}{1 + j\omega\frac{(L + Cr2R_L)}{2R_L + r - r\omega^2 LC}}. \quad . \quad . \quad . \quad (18)$$

Thus, if the difference in moduli of equations (18) and (17) is taken and added to the theoretical response curve of equation (9), the response will then be corrected for the effect of the capacitor on the signal. For small values of capacitor, this correction has little effect on the attenuation curve, but as the size of the capacitor is increased, the correction makes the response curve drop away steeply at the high frequency end of the curve.

PUSH-PULL TRANSDUCTORS

Although single-sided transductors are very useful in some applications, it is often necessary to have an output which is reversible and which is zero for zero input signal. For this type of circuit it is necessary to utilise a push-pull transductor. This consists of two normal single-sided transductors, operating with their control windings connected back to back. The outputs are then summed in such a way that only the out of balance current is fed to the load. The three most common types of summing (see Fig. 7) are series-resistor summing (*a*), T summing (*b*), and magnetic summing (*c*).[4] For series-resistor summing or T summing it is essential that the alternating-current supply for the transductors be obtained from two separate windings of the supply transformer, because of the connection through the common output terminal of the load rectifier. In Fig. 7, the bias winding has been omitted for simplicity.

In this paper the examination is confined to the series-summing type of push-pull arrangement. In this class of circuit, when the two halves of the unit are balanced, no voltage appears across the ends of the load resistance. When the transductors are unbalanced by the application of a control signal, a difference voltage appears across the output and causes the load current to flow. The direction of this current is dependent upon which transductor of the push-pull pair saturates earlier in the supply voltage cycle. The waveform of the voltage appearing across the load is shown in Fig. 8 (*a*). The length of the pulse is determined by the points of saturation of the halves of the transductor pair, since the voltage pulse begins when the first transductor saturates and ceases when the second unit saturates.

Series-Summing Circuit with Resistive Load.—The series-summing push-pull arrangement with a purely resistive load has been examined by Milnes and Law[4] who conclude that, theoretically, the time constant of a push-pull pair should be twice that of one of the transductor units working as a single-sided unit, provided the resistance of the control circuit is unchanged. Thus the time constant of a push-pull pair is $2\frac{Lc}{Rc}$, where Lc refers to one half of the pair, and is as previously defined. On checking this experimentally, it was found that the time constant varied in the same manner as for the single-sided, Fig. 2, and its value was nearly twice that of a single-sided unit, the measured ratio being about 1·9. The time constant was composed of a main time constant plus an auxiliary time constant, which also was about double that of the single-sided unit.

The push-pull pair with an infinite load has practically twice the time constant of a single-sided unit, with the same total resistance in the control circuit, but when a resistive load is connected across the series-summing resistors,

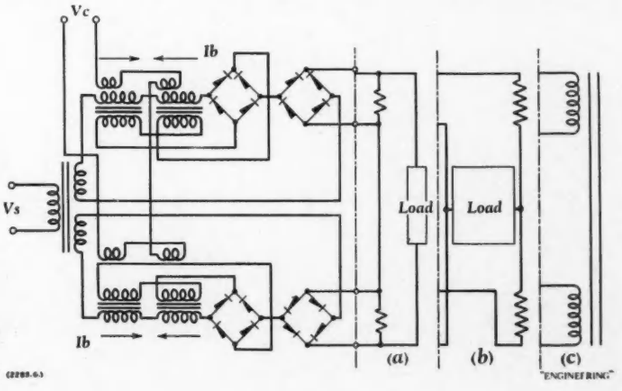

Fig. 7 Diagram of push-pull connections for the three usual types of summing: (a) series-resistor type, (b) T type, (c) magnetic type. The bias winding has been omitted for simplicity.

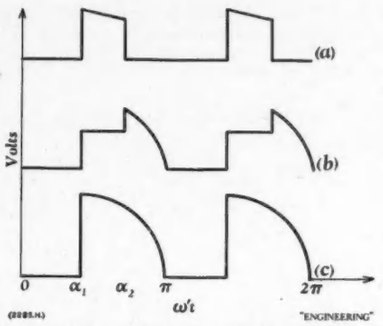

Fig. 8 Voltage waveforms: (a) across the load, (b) across the summing resistor Rs_B without a capacitor, (c) the same with a capacitor.

there is found experimentally to be a slight decrease in the time constant. Normally the time constant is proportional to $\frac{\Delta Vav}{\Delta Ic}$, so that any reduction in the former implies a reduction in the latter. This line of investigation appeared to be logical because there is a reduction in the voltage-time area sustained by the transductor that saturates later in the cycle, because of a feedback effect caused by the load current flowing through its summing resistor. This transductor will be termed unit B of a push-pull pair AB. The load current only flows in that part of the cycle in which the A transductor is saturated and passing current, and while the B transductor is unsaturated, and of high impedance. During this period the load current must return to transductor A via the summing resistor, Rs_B, of transductor B. Thus there will be a voltage drop across Rs_B, drop which reduces the voltage-time area of the B transductor.

From this

$$Tpp = \frac{Lc}{Rc}\left(1 + \frac{\Delta V av_B}{\Delta V av_A}\right). \quad . \quad (19)$$

Let this be equal to, say, $\frac{Lc'}{Rc}$, then

$$Lc' = Lc\left(1 + \frac{\Delta V av_B}{\Delta V av_A}\right), \quad . \quad (20)$$

where ΔVav_A, ΔVav_B, are the relative changes in total output voltages of transductors A and B, respectively. The experimental values obtained were in good agreement with this expression. It should be kept in mind that this effect is fairly small, the ratio $\frac{Tpp}{Tss}$ being about 1·9.

Series Summing Circuit with Inductive-Resistive Load.—The method of analysis adopted for this load was similar to that used for the corresponding single-sided load. This time the main difficulty was the determination of the total effective load circuit resistance, because of the complex circuit arrangement. The experimental results showed that the relative amplitude of the output, with respect to the input, at the frequency $\frac{1}{2\pi\sqrt{T_c T_2}}$, was no longer independent of the ratio $T_c : T_2$. The results further showed that the relative amplitude with respect to that at F = 0, was such that it was 0·5 at this frequency when $T_c = T_2$. These relationships showed that the expression was of the form

$$\frac{I_L}{Ec} = \frac{K}{Rc}\,\frac{1}{1 + j\omega T_c}\,\frac{1}{1 + j\omega T_2}, \quad (21)$$

where K is a constant for constant load conditions.

Having decided the form of the response, it was then necessary to determine the equivalent circuit parameters. The time constant of the control circuit, T_c, was taken as that calculated for a push-pull transductor feeding a non-inductive load of the same resistance value. This was of the order $1{\cdot}9\,\frac{Lc}{Rc}$, where Lc was the control inductance of one transductor, and Rc was the total control circuit resistance. T_2 was obtained from the equation

$$T_2 = \frac{1}{4\pi^2 Fo^2 T_c}, \quad . \quad (22)$$

where Fo was the measured frequency at which the phase shift between input and output was 90 deg. The values of Rc, Lc and L, could be easily measured, so that it was possible to obtain from equation (22) experimental values of the total load circuit resistance.

From the examination of the derived values of $T_2\left(=\frac{L}{R_{eff}}\right)$, it was found that the effective load circuit resistance could be reasonably represented by the expression $\left(R_L + \frac{2\,Rs\,r}{Rs + r}\right)$. Now $\frac{2\,Rs\,r}{Rs + r}$ was the effective "source" resistance looking back from the load terminals. As the "source" was symmetrical, $\frac{Rs\,r}{Rs + r}$ would refer to each half. This was the resistance between the ends of Rs because when the transductor was conducting, the rectifier resistance could be considered to be in parallel with Rs.

Thus the full expression was

$$\frac{I_L}{Ec} = \frac{K}{Rc}\,\frac{1}{1 + j\omega\frac{Lc}{Rc}}\,\frac{1}{1 + j\omega L\left(\frac{1}{\frac{2\,Rs\,r}{Rs + r} + R_L}\right)}. \quad . \quad . \quad . \quad (23)$$

This expression, while giving similar results to those given by the equation for the single-sided transductor, is fundamentally different from that type of expression. This is the equation for a two-loop circuit, in which each circuit contains a single energy store, and in which the loops are connected through a buffer amplifier.

With Capacitance on Output Side of Load Rectifier.—Capacitance may be connected in the circuit either as two identical capacitors, one across each summing resistor, or else as a single capacitor across the load. Consider the first possibility, and assume a purely resistive load. This may be expected to be analogous to connecting a capacitor across the resistive load of a single-sided transductor for which it was found that although there was no effect on the time constant, the value of $\frac{\Delta I_L}{\Delta Ic}$ was increased because of an apparent decrease in the value of the load resistance. Experimental evidence confirmed this view. Thus the effect was to increase the gradient $\frac{\Delta I_L}{\Delta Ic}$, (see Fig. 9), while the time constant was not changed. In addition, from Fig. 9, it will be seen that the linearity of the output was not reduced by the addition of the capacitor, whereas for a single-sided transductor there may be some loss in linearity.

Turning now to the alternative possibility with a resistive load of connecting the capacitor straight across the load, it was found that for this the effect was twofold. Firstly, there again was an increase in the load current for a given control current, while secondly, there was a reduction in the time constant. Considering the increase in load current, it was found that with a large capacitor the value of I_L tended to the value of I_L drawn by a load resistance of half the value of the resistance with the capacitor. Thus the effect of the capacitor was to reduce the effective value of R_L to half its actual value.

Considering the reduction in time constant and examining the waveform of various voltages, it was found that the important voltage waveform was the one obtained across the summing resistor of the B transductor. It will be seen in Fig. 8 (*b*), without capacitor, Fig. 8 (*c*), with capacitor, that the main change was in the height of the "step," which occurred before transductor B saturated and was caused by the load current flowing back to transductor A through this resistor. Without a capacitor, the value of this voltage was $\frac{Rs}{Rs + R_L}$ of the voltage across Rs_A. With a capacitor of sufficient size, so that it may be considered of zero impedance at the beginning, and for most of the duration of the pulse, then the voltage across Rs_B was the full value of that across Rs_A. But since there was no appreciable change in the current in the transductor, the effect was to increase the voltage across Rs_B in the ratio $\frac{Rs + R_L}{Rs}$.

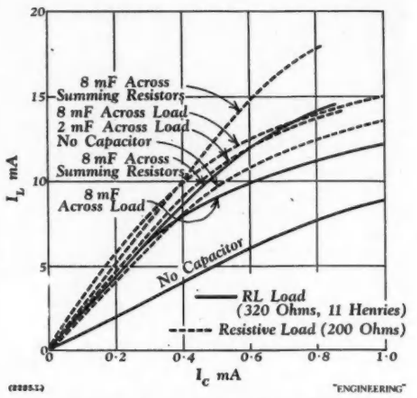

Fig. 9 Effect of control current on load current for different values of smoothing capacitor.

The next point examined was the variation of the current through Rs_B with Ic for various values of capacitor. This variation in current represents the area under the "step," and this was found to be constant for a given Ic and varying capacitance. For the optimum capacitor the height under the "step" was increased by a factor $\frac{Rs + R_L}{Rs}$, but since the area was constant the width must be multiplied by the inverse factor $\frac{Rs}{Rs + R_L}$. But the limits of the "step" width were α_1 and α_2, the angles of saturation, and since they were governed by Vav, it followed that ΔVav for a given ΔIc was reduced and hence the time constant of the B transductor was reduced to $\frac{Rs}{Rs + R_L}$ times the value with no capacitor.

The value of the time constant without a capacitor, as shown in equation (19) is

$$\frac{Lc}{Rc}\left(1 + \frac{\Delta V av_B}{\Delta V av_A}\right),$$

therefore with capacitance smoothing it becomes

$$\frac{Lc}{Rc}\left(1 + \frac{\Delta V av_B}{\Delta V av_A}\,\frac{Rs}{Rs + R_L}\right). \quad . \quad (24)$$

This was confirmed experimentally and some results are shown in Table IV.

TABLE IV.—*Variation of the Ratio* $\frac{Tpp}{Tss}$ *with* R_L *for Capacitance Smoothing*

Rs ohms	R_L ohms	$\frac{Rs}{Rs + R_L}$	$1 + \frac{\Delta Va_B}{\Delta Va_A}$	$\left(1 + 0{\cdot}86\,\frac{Rs}{Rs + R_L}\right)$	Measured ratio
200	105	0·65	1·86	1·55	1·52
	200	0·50		1·43	1·43
	400	0·33		1·27	1·27

It will be seen that there is very good agreement between the theoretical and experimental values. Further the product of the ratios, $\frac{Tpp \text{ with C}}{Tpp \text{ without C}} \times \frac{I_L \text{ with C}}{I_L \text{ without C}}$ for varying R_L is a constant for the same value of capacitor.

A desirable criterion of operation is that the ratio of current gain to the time constant, for any given set of conditions, should be a maximum. It was found that this ratio was not a maximum for the value of capacitor that gave the minimum time constant, since as the value of the capacitor was increased beyond this value, the increase in the current gain was

greater than the increase in the value of the time constant. The only limit was set by the fact that if the capacitance was too large, it caused excessive attenuation of the signal at the higher frequency end of the response curve. The value of capacitor to give the minimum value of time constant obeyed the relationship $CR_L = \frac{1}{8f}$. This is the relationship which was derived for the corresponding effect with the single-sided transductor with an inductive-resistive load.

Consider now an inductive-resistive load condition with a capacitor across each summing resistor. From Fig. 9 it will be seen that in these tests of this condition, the gain, load current to control current, was increased by approximately a factor of two, but as for a resistive load, there was no change in the dynamic response of the circuit. This was to be expected since the capacitor was in effect connected across a resistance. These observations bore out the consistency of the behaviour of the transductor under comparable conditions.

Turning to the possibility of connecting the capacitor directly across the inductive-resistive load, the increase of the current gain was in approximately the same ratio as that for a capacitor across each summing resistor, Fig. 9. But this time the curve was less linear as there was a dropping away in gain for large values of control current, and the operative range was somewhat reduced. Further, with this circuit the time constant was reduced, although not to the same extent as with the single-sided transductor.

It was found that for capacitors above a certain minimum value, the ratio $\frac{\Delta I_L}{\Delta Ic}$ was almost independent of the size of the capacitor. As with the resistive load the transductor behaved as if the load had been halved, instead of a capacitor having been added. This increased load current was not only caused by the storage capacity of the capacitor, but it was also caused by a greater $\frac{\Delta Vav}{\Delta Ic}$ gradient than that occurring without a capacitor.

As for the reduction in the time constant, the experimental results obeyed approximately the equivalent relationship to the single-sided transductor, thus

$$\frac{I_L}{Ec} = \frac{K}{Rc}\left(\frac{1}{1+j\omega\frac{Lc'}{Rc}}\,\frac{1}{1+j\omega L\left(\frac{1}{2R_L+\frac{2Rs\,r}{Rs+r}}\right)}\right) \quad . \quad . \quad . \quad (25)$$

In addition, the correction should be applied for the effect on the signal of the change of the equivalent load circuit, as described for the corresponding single-sided load by equations (17) and (18).

TWO-STAGE PUSH-PULL TRANSDUCTORS

Following the work carried out on single-stage push-pull transductors, investigations were made to see if the results obtained could be used in determining the performance of a two-stage unit. As only the series resistor summing push-pull transductor connection had been examined, a two-stage unit in which each stage was a series-summed pair, was chosen for examination. The control winding of the second stage, together with a series limiting resistance, formed the load of the first stage.

For the initial investigation, a purely resistive load was used for the output stage. In previous sections, for a resistive load, the load current had been assumed to respond simultaneously with the control current, so that for this, the load current of the second stage was in phase with the load current of the first stage. In addition, the control circuit had been shown to behave as a simple LR circuit, so that for the load current of the first stage, the response was the same as for the load current of an inductive-resistive loaded one-stage push-pull transductor. Thus the control current of the second stage had the response

$$\frac{Ic_2}{Ec} = \frac{K}{Rc_1}\,\frac{1}{1+j\omega T_{c1}}\,\frac{1}{1+j\omega T_{c2}}, \quad . \quad . \quad . \quad (26)$$

where T_{c1}, T_{c2}, are the time constants of the corresponding control circuits. It should be noted that the control circuit of the second stage is the load circuit of the first stage, hence it follows that

$$T_{c2} = \frac{Lc'}{R_s + \frac{2Rs\,r}{Rs+r}}, \quad . \quad (27)$$

where Lc' is the reduced inductance of the control windings of the second stage, and R_s is the total resistance of the control windings of this stage plus the series limiting resistor. Since the load current of the second stage was in phase with the control current of that stage, it follows that

$$\frac{I_L}{Ec} = \frac{K}{Rc_1}\,\frac{1}{1+j\omega T_{c1}}\,\frac{1}{1+j\omega T_{c2}}. \quad . \quad . \quad . \quad (26a)$$

On taking some experimental plots and comparing them with the corresponding theoretical curves obtained from equation (26*a*), it was found that there was good agreement. Thus a two-stage resistive loaded push-pull transductor may be considered as a single-stage unit with an inductive load, so far as the dynamic response is concerned.

From this conclusion, it was fairly simple to extend the results to a two-stage unit with an inductive-resistive load. For any single L R loop, the relationship between the voltage and the current may be expressed as

$$\frac{I}{V} = \frac{1}{R}\,\frac{1}{1+\frac{1}{j\,\omega\frac{L}{R}}}. \quad . \quad (28)$$

By comparison with equation (26)

$$\frac{I_L}{Ec_2} = \frac{k}{Rc_2}\,\frac{1}{1+j\,\omega T_{c2}}\,\frac{1}{1+j\,\omega T_{c3}},$$

and combining this with equations (26) and (28), it follows that

$$\frac{I_L}{Ec_1} = \frac{K}{Rc_1}\,\frac{1}{1+j\,\omega T_{c1}}\,\frac{1}{1+j\,\omega T_{c2}}\,\frac{1}{1+j\,\omega T_{c3}}, \quad . \quad . \quad . \quad (29)$$

where K is the gain constant $\frac{\Delta I_L}{\Delta Ic}$, and T_{c1}, T_{c2}, are as for the resistive load. T_{c2} is equal to

$$\frac{L}{R_L + \frac{2Rs\,r}{Rs+r}}.$$

A series of harmonic response tests was carried out and the results confirmed equation (29). By extending this technique, the expression can be made to apply to any number of stages.

CONCLUSIONS

For servo design it is an advantage to be able to predict the response of magnetic amplifiers for different types of loads. The following points summarise the observations made: (*a*) For resistive loads, the response, which is independent of the load, is almost completely determined by the time constant of the control circuit. (*b*) For inductive-resistive loads, the response is that of a second-order equation, of which the natural frequency is determined by the time constants of the control and load circuits. (*c*) For all loads the ratio of gain to time constant is improved by a factor of two to three by the addition of a smoothing capacitor across the output of the load rectifier. The minimum value of this capacitor is about $\frac{1}{8fR_L}$, but slightly larger values may be preferable.

Acknowledgments.—The author wishes to acknowledge the encouragement of Professor J. Greig and also the help and advice provided by Mr. A. G. Milnes and Mr. D. O. Burns of the Royal Aircraft Establishment, Farnborough.

APPENDIX

The transductors used in the experimental work were designed and supplied by the Royal Aircraft Establishment, Farnborough, for use with a 20-volt, 400-cycle supply. The cores were assembled from standard Mu-metal stampings (interservice type 522). Each alternating-current winding consisted of 200 turns, as did the self-excitation winding. After the two bobbins had been placed together, three control windings, each of 200 turns, and one bias winding of 100 turns, were wound on, while with a view to further work another winding of 10 turns was wound over the bias winding. Four of the above units were made so that with the associated rectifiers, it would be possible to connect them to form a two-stage push-pull amplifier. The rectifiers were of the selenium-disc type, of normal rating 18 volts per disc. The self-excitation bridge had one disc in each arm, while the load rectifier had two, and therefore a current path comprised six discs. For the push-pull transductor, two of the above units were connected with their main windings in parallel and their control and bias windings in series.

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Correspondence on this British Association paper will be considered for publication in "Engineering."

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PUBLIC WORKS

Congress and Exhibition in November

The Public Works and Municipal Services Congress and Exhibition for 1954 is to be held at Olympia, London, from Monday, November 15, to the following Saturday, November 20. The Rt. Hon. Harold Macmillan, M.P., the Minister of Housing and Local Government, will perform the opening ceremony.

The exhibition will again be a comprehensive display of contractors' plant and of equipment for all types of municipal engineering and services. In conjunction with the exhibition, there will be the congress at which nearly 30 papers will be presented on a wide variety of topics of interest to the general civil engineer as well as to county and borough surveyors. Of particular interest to engineers will be the following papers: "Some Problems in Mixing Granular Materials used in Road Construction," by K. E. Clare, R. H. H. Kirkham and R. S. Millard of the Road Research Laboratory; "The Contribution of Lighting to Safety on the Roads," by J. M. Waldram; "Organisation and Methods – Their Application to the Work of the Engineer and Surveyor," by Glanville Berry and P. L. Davies; "Mechanical Plant – Its Employment in Relation to Site Conditions," by W. K. Laing; "The Production of Stabilised Soil Road Bases," by H. L. Kerr. Prize-winning papers in the competitions organised by the promoters of the congress will also be delivered; two of these papers will be concerned with "Design, Preparation and Execution of Large Road Schemes" and "Mechanical versus Non-Mechanical Refuse Works – A Review of Costs," respectively.

The organisers of the exhibition and congress are the Municipal Agency, Limited, 70 Victoria-street, London, S.W.1.

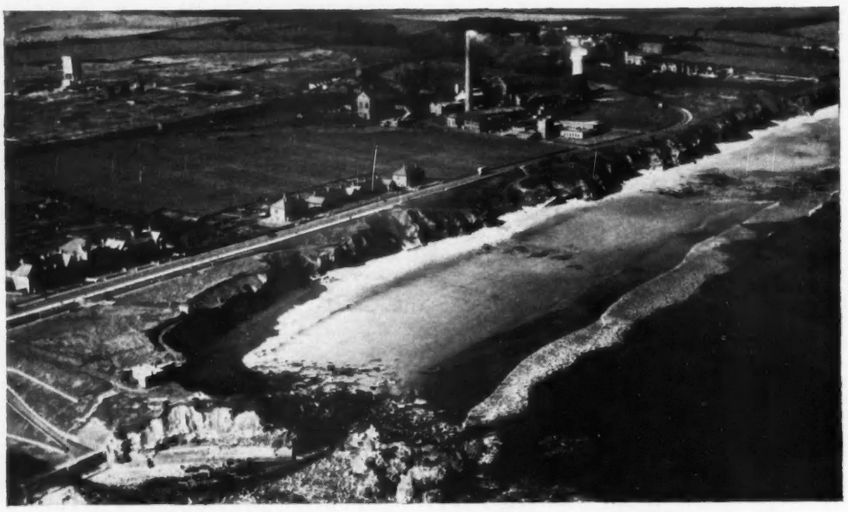


Fig. 1 Seaham, Co. Durham, showing Featherbed Rocks where the clay overburden has been washed away to within a few feet of the main coast road, parts of which have had to be closed while protective works were undertaken.

PROTECTION OF COASTAL LANDS AGAINST FLOODING AND EROSION*

DESIGN AND CONSTRUCTION OF SEA DEFENCES

By J. Duvivier, B.SC., M.I.C.E.

A civil engineer has been described as a person possessing enough skill to achieve for twopence what any more or less mechanically-minded person can do for sixpence, and if this is a fair definition it applies particularly in the case of coast protection, which is less of an exact science than any other branch of civil engineering by reason of the large number of variables which enter into the design of remedial works. The diagnosis of an erosion problem cannot be solved by reference to a code of practice; neither can sea walls and groynes be designed by the application of a formula, and no other branch of engineering depends to quite the same extent upon the experience and instinct of the designer.

The apparent simplicity of the art of coast protection has served all too often as an inducement to economically-minded but short-sighted persons to dispense with the services of engineers who are familiar with the ways of the sea and experienced in the pitfalls which beset the unwary. Almost any obstacle will prevent the sea from encroaching provided it is heavy enough and there is enough of it and unlimited funds are available for the replacement, repair or renewal of the obstruction from time to time when it is washed away.

Unfortunately, except in times of a national emergency, when 100 per cent. grants are available, this happy state of affairs does not apply, and sea defence engineers frequently practise their art on behalf of local authorities responsible for districts where a penny rate brings in something less than a hundred pounds and every ton of steel and cubic yard of concrete is weighed against the exacting demands of education and local housing.

Under these conditions there is scope for ingenuity and enterprise in the design of works and coast protection ceases to be a mere matter of interposing a mass of material against the momentum of storm waves; sections are designed with a due and proper regard to the stresses that will be called into play and a sense of balance is introduced into the design as a whole; new methods are tried and new materials are experimented with. The design of a sea wall or a series of groynes is not merely a haphazard selection of one of a large number of alternative designs, all equally feasible, but follows from the logical application of certain established principles to any special conditions encountered.

* Paper read before Section G of the British Association at Oxford on Monday, September 6, 1954. Abridged.

BASIC REQUIREMENTS

In a paper which he read before the Institution of Civil Engineers in 1947, the author stated "The design of sea defence works necessitates the observance of certain basic principles, which may briefly be stated as follows : (1) Due regard must be had in all stages of the design to the practical difficulties and risks of constructing works under tidal conditions and subject to sea action. (2) The consequences of future scour on the stability of the works must not be overlooked. (3) The worst possible conditions of storms and tide must be legislated for in the design." Strict observance of the first condition is essential if property is to be protected at a price commensurate with its value to the owner or to the community. Failure to make due allowance for these difficulties and risks while the work is in the design stage may result in extensive damage to works during construction, causing costly litigation and serious loss to the contractor or to his insurers. Observance of the second condition will ensure that the sea will not destroy or damage the works by undermining them, while observance of the third condition will ensure that the works will not be destroyed or seriously damaged if overtopped by a storm surge.

The problem of coast protection in the British Isles is as varied as the geology of the coastal outcrops, and although there may be a certain similarity between conditions at parts of the coast which are geologically similar, such as Aldeburgh and Southwold, or Walton-on-the-Naze and Herne Bay, no two problems are exactly alike, and each case has to be treated on its merits. In the following sections three recent sea defence schemes have been selected in order to illustrate how such investigations are handled, and the factors which have to be taken into consideration in designing the works. Conditions were entirely different at all three sites, and the schemes which were prepared for the protection of these three places differed widely, both in concept and in execution. The same principles of design, however, were applied in each case, any difference depending on the risks and interests at stake.

DEFENCE WORKS AT SEAHAM, CO. DURHAM

Urban, county and commercial developments which had been allowed to proceed in the past without regard to the proximity of the sea and the instability of the cliff gave rise to a sea defence problem which could not be solved until 1949, when the passing of the Coast Protection Act enabled the Local Authority to promote a scheme for the protection of the coast road. The cliffs are about 50 ft. high and are composed of magnesian limestone capped by boulder clay of varying thickness. The limestone is mainly soft and friable with veins of hard material and offers less resistance to erosion by the sea than one would expect from the rugged appearance of the cliffs. The softer material in the exposed face of the cliff is scoured by the waves and undercut until the overhanging rock falls on to the beach; this in turn disturbs the boulder clay overburden and slides occur until the clay once more assumes a stable slope.

For a distance of nearly 1,200 ft. north of the Featherbed Rocks, Fig. 1, the slipping of the clay overburden had driven the top of the clay slope landward to within a few feet of the Seaham-Sunderland main road, parts of which had to be closed while piecemeal protective works were erected at beach level. The terms of reference were to submit a report on the causes of the erosion with recommendations for stopping it and an estimate of the cost of the works proposed. Factors to be taken into consideration were: the extremely difficult access to the site of the works for plant and materials; the fact that bed-rock lay, in places, at depths up to 13 ft. below the crest of the beach; the exposure of the site to the full force of all gales between north-east and south-east; the absence of any clear indications of the existence of a littoral drift of shingle from north to south in conformity with the north to south drift which takes place elsewhere on the East Coast; and lastly, uncertainty as to the depth to which the harder veins of rock would permit steel piling to be driven.

Several designs for a sea wall to protect the face of the cliff were considered and two alternatives were submitted; where the rock occurred at depths exceeding 5 ft. below beach level it was considered that a sea wall of granite concrete founded on a line of interlocking steel sheet-piles driven down into the rock, with concrete buttresses at 20 ft. intervals along the back between the sea wall and the cliff, and with heavy steel tie-rods embedded in them with their inner and lower ends grouted deeply into the rock face of the cliff would avoid deep excavation between tides and would be safer and easier to construct. (See Fig. 2.) The cover of concrete over the reinforcing steel was to vary from 9 in. at beach level to just over 4 in. at deck level to allow for abrasion. Where the rock occurred at depths less than 5 ft. below beach level the sheet-piling was to be omitted and the wall founded directly on bed-rock. Further investigation of seasonal beach movements and an examination of the limestone reefs which outcropped in the foreshore showed, however, that it would be economically possible to excavate down to rock level for the greater part of the 3,700 ft. of wall, and it was eventually decided to omit the sheet-piling and found the wall directly on the rock throughout its length. A typical section of the wall as built is shown in Fig. 3.

A concrete apron was constructed along the seaward side of the foundation, terminating in a toe carried down 2 ft. 6 in. into the rock to prevent undermining of the wall during periods when the shingle might be levelled out by onshore gales exposing the rock below. The wall was built in horizontal layers, followed by the toe wall and apron which were constructed

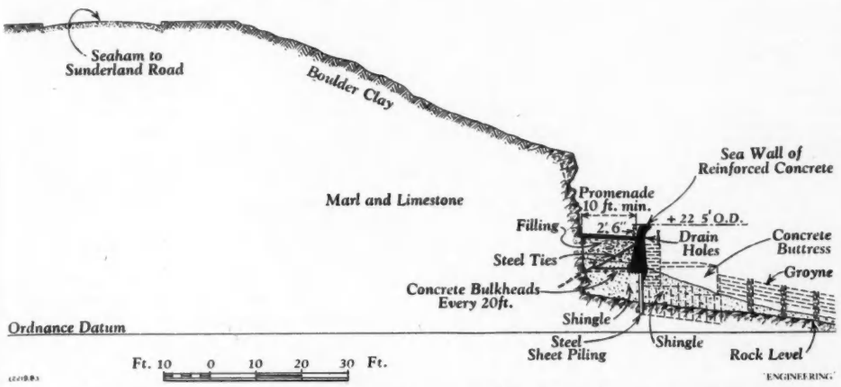


Fig. 2 Seaham sea defences. Original design for the retaining wall above sheet piling where the bed rock was more than 5 ft. below beach level.

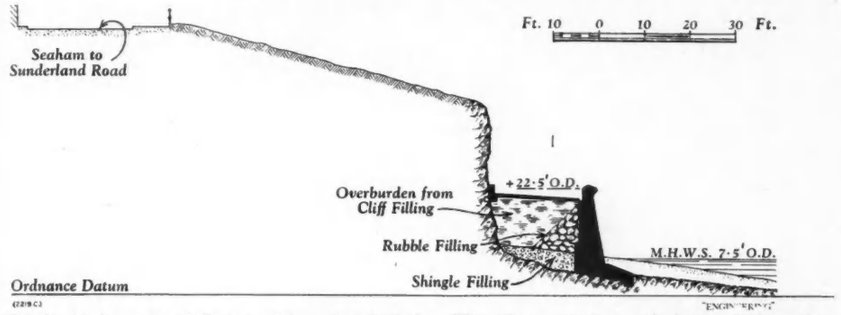


Fig. 3 Seaham sea defences. The original design (Fig. 2) proved impracticable, and the mass-concrete wall founded on the rock as shown here has been constructed.

during neap tides under the shelter of a great mound of shingle excavated by drag-line machine and tipped so as to form a protective embankment between the wall and the sea. This work of forming the embankment is shown in Fig. 4. Construction by this method would not have been possible in the days before mobile excavators were invented, and the construction of sea defence works has been greatly facilitated by reason of the great volume of beach material that can be excavated in a short time by mechanical means.

At the time of writing, the sea wall is nearing completion. It successfully withstood the force of the gale on January 31, 1953, notwithstanding its incomplete state, and no damage was caused to the permanent works. Fig. 5 shows the sea pouring in through the scupper holes in the parapet during the storm. The bottom of these scuppers is at a height of 12 ft. above M.H.W.S.T. The space between the wall and the cliff was filled with spoil from the Vane Tempest Colliery and decked over to form a waterproof decking and promenade. Behind the wall there is an additional "flood" wall to canalise the water that comes over the parapet of the sea wall during gales until it drains back to the sea through the scupper openings.

The lack of any obvious indication of a littoral drift of shingle from north to south was viewed with suspicion, and the possibility of building up and holding a beach of shingle or sand or both by means of groynes was investigated. A geologist was employed to examine the material on the foreshore to see if that would throw any light on its origin and so point to a resultant movement in one direction or another. Unfortunately geological conditions on that part of the coast proved to be such that no definite conclusions from the geological investigation were possible. One of the facts that did not fit in with the theory of a north to south drift was the absence of the large accumulation of beach material in the angle of the cliffs just north of Featherbed Rocks.

While searching through a number of old records in the local library a photograph was found which showed that 50 years before there was a very large accumulation of sand and shingle at this corner of the coast. Further inquiries elicited the fact that the extraction of shingle from this point which took place on a large scale during the construction of Seaham Harbour continued for other purposes on a still considerable scale until as recently as 1949. An experimental groyne was built in 1952 and experience of the working of this groyne has shown that although the direction of the littoral drift is reversed at times for considerable periods, nevertheless year in year out the tendency is towards the south. A record of wave movements was established while constructional work was in progress, and it was found that during the twelve months from June, 1952, to May, 1953, waves approached the shore from a direction north of the normal on 78 days, south of the normal on 58 days, and at right angles to the shore on 82 days; the record showed that, generally, waves approaching from the north were bigger than waves approaching from the south, and hence would have a greater transporting power; on the remaining 147 days either the sea was calm or there was no record.

It is considered very desirable to harness the seasonal along-shore movement of shingle to relieve wave pressure on the sea wall, and a proposal has been submitted to and approved by the Local Authority, and awaits sanction and grant aid by the Ministry of Housing and Local Government, for the construction of 13 groynes 150 ft. long spaced 250 ft. apart. The construction of these groynes will present its own technical problems. The beach is far from ideal for the construction of groynes. The limestone is not readily penetrated by piles, while excavation of the lower foreshore to any appreciable depth with a view to founding a concrete groyne directly on the rock is so difficult as to be, in many cases, an impossibility. Some other method will therefore be devised, although, pending the result of further tests, it is not yet clear what that method will be.

THE LINCOLNSHIRE COAST

The Lincolnshire coastal lands are mainly agricultural with occasional small towns and

Fig. 4 Excavating for the toe wall and apron in front of the Seaham wall. The spoil was formed into a temporary protective embankment.

Fig. 5 Seaham during the storm of January 31, 1953, with the water pouring through the scupper in the parapet.

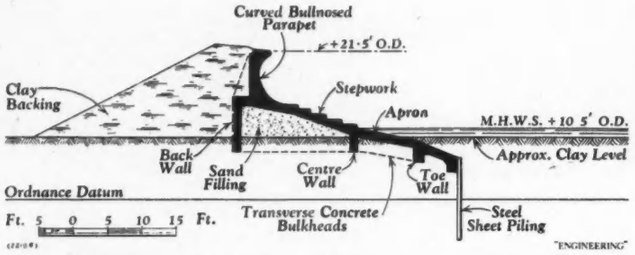


Fig. 6 Huttoft, Lincolnshire. A cellular-type wall built in 1944, with transverse bulkheads at 25 ft. intervals. The bulkheads will limit damage if the wall is ever breached.

villages sheltering behind the sea embankment. The land is low-lying for several miles back from the coast and widespread inundation has occurred from time to time when the natural or artificial defences have been breached by the sea. The general level of the ground near the coast is between 8 ft. and 11 ft. above Ordnance Datum. As the level of M.H.W.S.T. is approximately 10 ft. 6 in. above Ordnance Datum, while the level of the tide at high water on January 31, 1953, has been estimated at about 16 ft. 6 in. above Ordnance Datum it is obvious that coast protection is a factor of considerable importance in the lives of the inhabitants.

Prior to 1943 the maintenance of 19 miles of coastline north of Skegness was entrusted, under the terms of the Land Drainage Act, to the Alford Drainage Board, who employed for this purpose two gangs of seven or eight men under the direction of two foremen highly skilled in the ancient arts of thorning and faggoting the sandhills. In 1943 a concrete wall which had been built at Trusthorpe between the wars was completely destroyed by a severe storm over a distance of 600 ft., and a certain amount of damage was caused to agricultural land by flooding. A new wall was built across the breach using, for the first time on this coast, reinforced concrete for revetting the seaward slope. During the next six years a mile and a half of new sea wall was built and two and a half miles of the existing defences were reinforced in the Sutton and Mablethorpe area under a series of contracts as and when the funds were made available by the Board or by the Ministry of Agriculture.

The terms of reference for the various works naturally varied somewhat depending upon whether an existing wall was to be strengthened or a new wall had to be built in front of a previously unprotected part of the coast, but the requirement was the same in each case, namely, to recommend what should be done to protect the frontage concerned against flooding by storms and tidal surges and to do it as cheaply as possible utilising uncontrolled materials as far as possible. One of the first of the new cellular types of sea wall was built in 1945 at a place called Huttoft, 3½ miles south of Mablethorpe.

By contrast with Seaham there were no access problems in Lincolnshire. At Huttoft the last trace of the sandhills had been swept away by the sea and it was possible to walk up a gently rising slope from the beach into the field behind through a gap in the defences 1,000 ft. wide. The foreshore, which was approximately 1,000 ft. wide at low tide, was found to consist of a deposit of soft alluvial clay or " warp "covered with a seasonal deposit of medium to fine sand of varying thickness. Borings made at the site of the wall, however, revealed a layer of warp only 5 ft. thick overlying fine sand and silt more than 50 ft. deep. Warp erodes rapidly when exposed to wave action, and at Huttoft it eroded to a depth of 4 ft. in less than a year over a wide area.

There is no pronounced littoral drift along the north Lincolnshire coast such as is found to occur along the Holderness coast of Yorkshire. The sand is constantly shifting and after on-shore gales it is scoured away from the upper part of the foreshore, leaving hollows which are gradually filled again with sand after the gale has subsided. The site of the work was fully exposed to gales from between due north and south-east, and the ever-present danger of serious flooding through an open gap 1,000 ft. long in the defences, required that the design should provide for some form of phased construction under which partial protection against the worst effects of a flood could be obtained in the shortest possible time and in advance of the completion of the scheme as a whole. The weakness of the ground on which the wall had to be built necessitated the adoption of a wide base so as to spread the load as much as possible and a stepped sloping profile with a curved bull-nosed parapet was designed for the seaward face of the wall to destroy the momentum of the waves by stages and turn the unexpended part of the wave back to the sea.

A straightforward method of closing a breach, and one that was extensively adopted on the Lincolnshire coast after the 1953 flood, is to build an embankment from end to end, subsequently revetting the seaward face with stone or concrete. This method, however, has certain disadvantages. There were no facilities and no money available in 1945 for the importation of thousands of tons of blast-furnace slag from Scunthorpe, while if the embankment had been made of clay it would have settled unevenly with the passing of time and special measures would have had to be taken to allow the revetment to adjust itself to the settlement. This in itself would have been a source of weakness. A revetment of this type is very vulnerable to wave action during construction and to the effects of scour if the finished work is seriously overtopped. A fundamental lesson to be learned from the recent disastrous floods is that sea defences in low-lying areas should be of such a form that though overtopped by the sea or by spray under abnormal conditions, they must not be breached by these conditions. This is easily achieved when starting *de novo* with the construction of an entirely new sea wall by building the wall in such a form that it does not depend upon the material behind for support; in fact this is a pre-requisite in such cases, as the wall must be stable during construction.

PERMANENT STRUCTURES

At Huttoft the new wall, shown in Fig. 6, was designed for construction in two main stages. Under stage 1 the sloping apron and stepwork were completed to approximately half the height of the finished structure. The sand filling under the apron and stepwork was contained between three parallel walls of concrete. The front or " toe " wall was carried well down into the warp. The back wall terminated at a level of 3½ ft. above high water and the top of the centre wall was about 4 ft. lower. The spaces between these walls were subdivided into a number of boxes by means of transverse concrete bulkheads 25 ft. apart. The compartments were filled with sand on which the reinforced-concrete apron and stepwork were built. This comprised stage 1 which gave partial protection to the land behind. Subdivision of the substructure of the wall into a number of self-contained units or boxes in this way limited the risk of damage during construction to a 25 ft. length. It will also localise the damage if a bay of apron or stepwork is breached at some future date by another storm surge.

Under stage 2 a curved " bull-nosed " superstructure was added; this was securely anchored to the slab below, and clay filling was placed against the back of the wall. As a protection against undermining a line of interlocking steel sheet-piling was driven just seaward of the toe of the wall and the intervening space filled with concrete. The only damage that was done to the wall during construction was caused by the failure of the contractor to adhere to the sequence recommended in the specification; instead of completing one compartment at a time from front to back he covered four compartments with half the finished width of stepwork; a sudden storm scoured away the sand filling of the compartments and destroyed four days' work. The only damage that the author observed when he examined this wall after the 1953 storm was a horizontal crack about half-way up the curved face of some of the units. As the top of the wall was only 5 ft. above tide level and the

Fig. 7 Norfolk Coast. New wall under construction at Sea Palling, 1953, where the North Sea floods at the beginning of that year had so eroded the sand dunes that only a quarter of their original cross-section was left.

waves must have been 9 or 10 ft. high the wall must have received a severe hammering during the height of the gale.

In the case of a similar wall, which was built at Church Lane, Sutton, in 1948, the coping was 9 in. higher, the top of the wall being 12 ft. above M.H.W.S.T. and a concrete promenade and flood wall were built at the back of the sea wall. The storm seems to have had little effect on the sandhills and bathing huts along the back of this wall, owing largely to the excellent sandy beach which has been gathered and held by the new groynes which were built under the scheme. But for this, more spray would undoubtedly have come over the top and the vegetation on the sandhills would have suffered.

The same principle of a cellular foundation, sealed off in lengths of 25 ft. as the construction moves along and surmounted by a curved oversailing parapet was adopted in the case of the new walls at Sea Palling and Horsey on the Norfolk coast, which were built during the latter part of 1953. (Fig. 7.) The weakest section in the sandhills has, in the past, always been at Horsey where the sea has frequently broken through; but a gradual weakening of the dunes during recent years in the vicinity of Sea Palling resulted in a breach being formed here as well as at Horsey when the storm of January 31 – February 1, 1953, eroded the dunes so severely that, for considerable lengths, less than a quarter of their original cross-sectional area was left.

To be continued

Correspondence on this British Association paper will be considered for publication in "Engineering."

DUSTLESS FETTLING

CONTROLLING THE DUST AT ITS SOURCE

Portable grinders and chipping hammers produce considerable amounts of harmful dust, but it is difficult to provide them with any orthodox form of dust-extraction equipment. When fettling can be done at a bench, with cowling and dust-extraction plant, it may be possible to control the dust successfully, but in many cases bench work is impossible, and the fettling must be carried out on the shop floor. The problem has been investigated by a number of workers, and experimental equipment has been evolved which has been very successful. Earlier this year two papers presented to the Institution of Mechanical Engineers* stated at length the methods used to study the problem, and described the "Dryductor" equipment then evolved.

Two modified fettling tools, based on the work of the joint authors of the paper, and on the manufacturers' experience in making dustproof rock drills, are now in normal production by Holman Brothers, Ltd., Camborne, Cornwall. They are a hand-held portable pneumatic grinder and a pneumatic chipping hammer. Prototypes of both tools were studied under various working conditions by the photographic technique developed by the joint authors of the paper, and both were found to give satisfactory results. Production models have now been under test for some time, both in the manufacturers' own works and in other factories, and it has been possible to gain operational experience under normal working conditions.

CHIPPING HAMMER

Of the two tools the chipping hammer gave the least trouble to the designers. The production model is of a simple form which, as far as the operator is concerned, is virtually no different from a standard tool without dust-extraction equipment. The hammer has a 1⅛-in. bore, a stroke of 2½ in., is 11¼ in. long overall and weighs 13 lb. The chisel has a port or air passage right through it, connected at the rear end, through the hammer body, to a ⅜-in. diameter suction hose. Near the chisel point the air passage divides into two; there are thus two air ports at the working end, one in each face. An air current, induced by any one of several different methods, is caused to pass into the two air ports in the chisel point, and through the hammer body and suction hose to a point where the dust can be filtered and removed. By adjusting the vacuum in the suction line, the whole of the dust-producing area at the chisel point is swept by the air entering the ports, and the dust is drawn away completely. Experience has shown that while the respirable dust and the larger visible particles are removed from the source, there is no trouble with choking of air passages; larger pieces of material which the chisel may detach, and which are harmless, are not drawn into the ports.

The chisel is of such a form that many regrindings are possible before the twin ports are ground away, though at present the life of the chisel is shorter than that of a normal solid one. Development work is proceeding, however, on a chisel with a continuous port, which will permit grinding to be carried out in the usual way until the tool is too short to be used.

PORTABLE GRINDER

The dustless portable grinder is again a modification of one of the manufacturers' standard tools, but its use is subject to certain limitations. The investigations showed that the dust follows the wheel round, adhering to its periphery. It was therefore necessary to enclose the wheel as fully as possible, and provide a dust-extracting air-current all round the cowl. This does, to some extent, restrict the use of the grinder where it is required to work into relatively small radii, but it should be emphasised that development work on the problem is proceeding, with a view to increasing the amount of wheel periphery available to the operator. On flat surfaces or on the outsides of radii, the tool is as easy to use as a normal portable grinder. It is in production with a combined guard and dust-extraction cowl for a 5-in. diameter wheel, working at a free speed of 4,400 r.p.m. The grinder is 20½ in. long, and weighs 12¾ lb. complete.

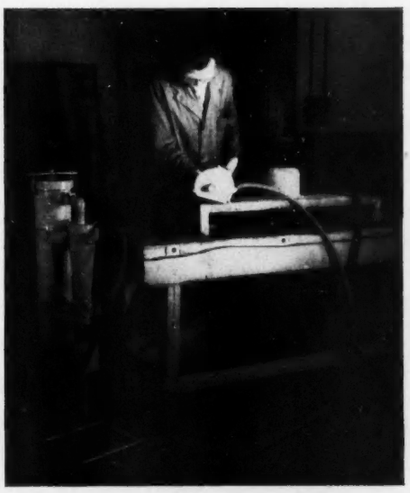
DUST DISPOSAL

Both tools are provided with a connection for a rubber suction hose. This can be coupled to any suitable suction source, according to circumstances. Where several tools are to be used, as in a foundry dressing shop, the simplest arrangement is to equip the shop with a number of suction points adjacent to the compressed-air points. These are connected to a suction main, which is exhausted by a normal rotary exhauster of suitable size and vacuum depression, and the dust is drawn to a central filter plant, where it is removed for disposal. Arrangements may be made to interlock the compressed-air and suction valves, so that when a tool is coupled up it cannot be used unless the suction valve is open.

As an alternative, where from one to three tools are to be used, either in a fixed position or at various points about a factory, a small suction unit, incorporating an Eductor, produced by the makers of the tools, is available. This unit is of light weight and small size, and can easily be carried by one man. It consists of a Venturi-type ejector, by means of which suction is induced by the compressed-air line, a cyclone for the extraction of the larger dust particles, and bag filters for the final cleaning of the air. Detachable containers are fitted to hold the dust.

Dust extraction on the same basic principle as the Dryductor system, as applied to the two portable tools described is, of course, equally applicable to many other types of equipment, and development work is in hand on swing-grinders, and pedestal and bench grinders. The latter is in an advanced stage. In all applications of this type an important advantage is that the total amount of air extracted from the shop is very small compared with that removed by high-rate fans, with cabinets of orthodox construction, and the effect on shop space-heating in cold weather is therefore negligible. For this reason the equipment described, though it was developed for use with portable tools, can offer considerable advantages when used with static installations.

The Holman dustless pneumatic chipping hammer has a suction hose for the extraction of dust through the chisel point.



For small installations, a pneumatic Eductor can be provided to produce the necessary vacuum. It is shown here in use with a dustless portable grinder.

* "The Observation and Control of Dust at Portable Abrasive Wheels," and "The Observation and Control of Dust at Pneumatic Chisels." By W. B. Lawrie, M.Sc., A. T. Holman, O.B.E., and E. B. James, April 9, 1954.

SINGLE-SPINDLE AUTOMATIC SCREW-MACHINE

METRIC SPECIFICATION AND SPECIAL INDEXING MECHANISM

The latest addition to the range of single-spindle automatic screw machines made by B.S.A. Tools, Limited, Mackadown-lane, Kitts Green, Birmingham 33, is designed to meet the needs of the European market, and for those British and other users who prefer the Continental type of machine. It has a maximum capacity in round stock of 18 mm., and is built to metric specifications. In basic principle the machine resembles the others in the range, but it incorporates several new features.

The design of the machine is based on the company's " L " or open-front type, in which the camshaft is at the front, but clear of the turret and slides. This arrangement, which somewhat resembles the letter L in plan, gives increased accessibility to the tooling area, and allows the swarf to fall clear without obstruction. Access to the cams, gears and other parts of the machine is provided by hinged doors or swinging covers, which are retained in the closed position by spring catches, and can be opened instantly when necessary. All the working parts are thus completely enclosed, but maximum accessibility for setting and adjustment has been retained. Observation windows are provided in the covers where necessary.

WITHDRAWAL FOR DEEP DRILLING

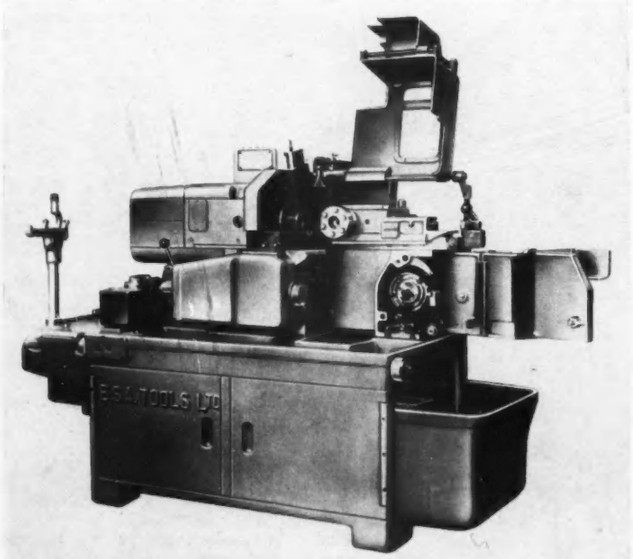
A range of work-spindle speeds from 40 to 4,500 r.p.m. is available, by means of pick-off gears and a gearbox housed in the base of the machine. The gearbox is arranged for two speeds, forward and reverse, under automatic control, and a four-speed gearbox is also available if required. The turret, which is of the six-station type, is located after each index by a plunger mounted in the base of the slide body, which enables the latter to be cut away considerably to give additional clearance to tools mounted on the rear cross slide. Arrangements are made for straight withdrawal and advance of the turret without indexing, when required. This operation can be carried out as often as necessary and at any point in the machine cycle. Deep holes can thus be drilled with a single drill, the appropriate number of withdrawals being made for swarf clearance. There is also provision for double indexing when the machine is set up with one or more of the stations on the turret not in use. An additional roller and cams, which are standard equipment, are fitted, and the turret then indexes twice at one stroke, missing a station as required. The standard stroke of the turret is 50 mm., but this can be increased to 70 mm. by means of a set of conversion parts.

DOUBLE AND SINGLE TOP SLIDES

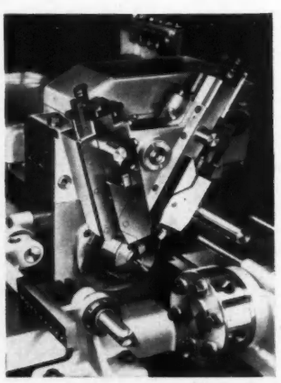
Two cross slides are provided and both are fully supported right up to the cutting position. At the same time, both slideways are protected from swarf by means of guards or aprons which are hinged to the cross slides, and fall down clear of the slideways at the extreme forward position. The standard machine has a single top slide which is mounted on the headstock. This slide is removable as a complete unit and in its place a double top-slide unit can be fitted. This unit is complete with its own camshaft and is driven by a vertical shaft from the main worm shaft of the machine. It is only necessary to remove two nuts to change the top-slide units.

Lubrication of the cams and gears is by splash-trays and oil reservoirs, and a Tecalemit " Bijur " pump is fitted to supply oil to all bearings, individual metering valves being provided at each lubrication point. The oil pump is power driven. The turret, which, because of its rapid movement cannot be connected to the automatic lubrication system, is provided with an independent hand-operated Tecalemit pump and an oil reservoir in the turret body casting.

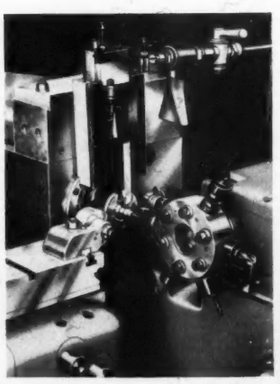
A large range of special fittings is available, and it is possible to carry out a variety of operations such as cross drilling by using the appropriate extra fittings.



Hinged guards on the B.S.A. single-spindle automatic screw machine give maximum accessibility.



Either a single top slide or the double-slide unit shown can be fitted to the machine.



The tooling area provides ample clearance for swarf, and the tools are readily accessible.

LAUNCHES AND TRIAL TRIPS

M.S. " Tove Vendila."—Single-screw oil tanker, built and engined by Burmeister and Wain, Ltd., Copenhagen, for A/S Dampskibsselskabet " Vendila," Copenhagen, Denmark. Main dimensions: 526 ft. between perpendiculars by 72 ft. by 38 ft. 3 in. to main deck; deadweight capacity, 18,100 tons on a summer draught of 29 ft. 6½ in.; oil-tank capacity, 24,400 cub. metres. B. & W. eight-cylinder single-acting two-stroke oil engine, developing 7,380 b.h.p. at 115 r.p.m. Engine arranged for burning Diesel or heavy oil. Loaded speed, 15 knots. Trial trip, August 18.

M.S. " Perang."—Single-screw cargo vessel, built by William Gray & Co., Ltd., West Hartlepool, for the Elder Dempster Lines, Ltd., Liverpool. Main dimensions: 425 ft. between perpendiculars by 60 ft. by 38 ft. to shelter deck; deadweight capacity, 9,800 tons on a draught of 26 ft. Scott-Doxford four-cylinder opposed-piston oil engine developing 3,300 i.h.p., constructed by Scotts' Shipbuilding and Engineering Co., Ltd., Greenock, and installed by the shipbuilders. Service speed, 11½ knots. Launch, August 30.

M.S. " British Patrol."—Single-screw oil tanker, built and engined by Swan, Hunter, and Wigham Richardson, Ltd., Newcastle-upon-Tyne, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 515 ft. by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, 16,000 tons on a summer draught of about 30 ft. Swan Hunter-Doxford six-cylinder opposed-piston oil engine, developing 6,400 b.h.p. at 115 r.p.m. in service. Speed, 13¾ knots. Launch, August 30.

M.S. " Border Minstrel."—Single-screw oil tanker, built by the Blythswood Shipbuilding Co. Ltd., Scotstoun, for the Lowland Tanker Co., Ltd., (Managers: Common Brothers, Ltd.), Newcastle-upon-Tyne. Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 16,000 tons. Rowan-Doxford six-cylinder two-stroke opposed-piston oil engine, developing 6,800 b.h.p., constructed by David Rowan & Co., Ltd., Glasgow. Launch, August 31.

S.S. " Kingston Emerald."—Single-screw trawler, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for the Kingston Steam Trawling Co., Ltd., Hull. Main dimensions: 189 ft. by 32 ft. by 17 ft. 6 in.; gross tonnage, about 800; fishroom capacity, 16,940 cub. ft. Triple-expansion steam engines constructed and installed by Charles D. Holmes & Co., Ltd., Hull. Steam generated by one oil-fired multitubular boiler. Launch, August 31.

S.S. " Nuddea."—Single-screw cargo vessel, built by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for the British India Steam Navigation Co., Ltd., London, E.C.3. First vessel of a new series for these owners. Main dimensions: 514 ft. by 67 ft. by 42 ft. to shelter deck; gross tonnage, 10,130; refrigerated-cargo capacity, 30,000 cub. ft. Parsons double-reduction steam turbines. Steam supplied by two oil-burning water-tube boilers. Service speed, 16½ knots. Trial trip, August 31.

H.M.S. " Tide Austral."—Fast replenishment oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the Admiralty, London, S.W.1. Length 550 ft. between perpendiculars by 71 ft. beam; deadweight capacity, 17,700 tons. Launch, September 1.

COMBINED LOADER AND EXCAVATOR

BUCKET ON TURNTABLE BASE

The Ahlmann swing-shovel, which is made by Ahlmann-Carlshütte A.G., of Rendsburg, Germany, and marketed in Great Britain by Abelson and Company (Engineers), Limited, Sheldon, Birmingham 26, is available in three sizes, the largest being capable of handling loads up to 1 ton 4 cwt. or 1½ cub. yd. The machine is designed to operate as a loader, working from stock-pile to vehicle, or as a light excavator. It has a maximum discharge height of 12 ft. 10 in. Extra fittings, which can be attached in place of the shovel bucket, are available to convert the machine into a crane, a light bulldozer, or a snow-plough. Buckets of various sizes can be fitted to each of the three models, in order to utilise the full lifting and carrying capacity, according to the density of the material being handled. The bucket is carried on a swivelling arm which is capable of slewing through 180 deg. independent of the chassis, and all the motions of the bucket and bucket-arm are hydraulically operated.

The chassis is of fabricated steel, carried on four pneumatic-tyred wheels. The front wheels, which are used for driving, are of large diameter, with heavy traction-type tyres. Water ballasting is used to improve the tractive properties. Steering is from the rear wheels, which are of smaller size. The rear axle is pivoted in the centre, which permits it to align itself with uneven ground. The power unit, which is a Deutz four-stroke cycle, air-cooled Diesel engine, is mounted between the axles, and drives the front wheels through a large single-plate dry clutch, a four-speed straight or "crash" type gearbox and a differential. An independent reversing gearbox is provided, and the machine can thus travel in either direction in any one of the four speeds. The engine is equipped with an electric starter, and is designed for quick starting over the temperature range − 40 deg. to + 140 deg. F. A feature of the engine mounting is the accessibility of the unit for servicing purposes. Both bonnet sides are retained in position by spring clips, and when they are removed, the complete power unit is exposed.

HYDRAULICALLY-CONTROLLED SHOVEL BUCKET

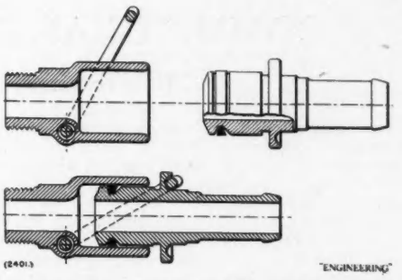
The shovel bucket is carried by a fabricated-steel arm which is mounted on a ball-bearing turntable over the driving wheels. A hydraulic cylinder and ram, of the three-stage type, raises the bucket arm, and a separate cylinder is provided for tilting the bucket. Slewing of the bucket arm is by means of two further hydraulic cylinders mounted horizontally on the chassis, and connected by short chains to the swivelling base. Hydraulic power for the bucket control cylinders is provided by a hydraulic pump driven by an extension from the crankshaft.

The shovel is controlled from the near side, the travel controls comprising a steering wheel, clutch, foot brake and handbrake, and a hand-operated differential lock which can be used to provide positive traction on both driving wheels on loose or slippery ground. Control of the bucket and bucket arm is through hydraulic valves, with hand levers mounted at the driver's right hand. From the driving position the driver can cause the machine to travel in either direction at speeds ranging from 1¾ to 12 m.p.h. and can raise, lower, and slew the bucket through 90 deg. either side of the chassis as required. By jerking the bucket-tilting cylinder control the bucket can be shaken when in its discharge position.

ADAPTABLE IN USE

When rigged as a shovel, the machine can be used for loading almost any kind of material from a stock pile to a vehicle. For this purpose it picks up a load, drives alongside the vehicle, and slews its bucket through 90 deg. to deposit the contents. The hydraulic control and positive drive of all the bucket arm motions enables the load to be deposited with great precision, and the bucket can, if necessary, be used to level the load in the vehicle in order to utilise its full carrying capacity. At a recent demonstration a motor lorry was loaded with 6 tons 6 cwt. of gravel by the shovel in 4 minutes. In the same rig the shovel can be used for light excavating, either from a vertical or sloping face, or from below ground level. The bucket arm can be lowered sufficiently to enable the machine to dig approximately 16 in. below ground level at each pass. Similarly, the machine can be used for back-filling, either by lifting and dumping, or by pushing material into a trench.

With the crane fitting, a fabricated tubular bracket and hook mounted in place of the bucket, the shovel can lift, slew and travel in the same way as an orthodox mobile crane. It has two independent brakes, and is easily arranged for use on public highways.



In the Victor air-hose coupler, when the air-pressure is turned on a rubber sealing-ring seals the joint, which cannot then be uncoupled until the pressure is released. A spring bridle locks the parts together.

SELF-SEALING AIR HOSE COUPLER

A new type of coupler for air hoses, shown in the accompanying illustration, has been introduced recently by Victor Products (Wallsend), Limited, Wallsend-on-Tyne, Northumberland, which, it is claimed, provides instantaneous self-sealing with no leaks.

The coupler, which is suitable for both high- and low-pressure air hoses, incorporates a rubber sealing ring of special design. To connect, the stem of the coupler is inserted into the spud, and the air supply is turned on, causing the rubber ring on the stem to "rock" forward, giving the initial sealing action. As the air pressure is increased so the sealing action of the coupler is completed.

NO TOOLS

No spanners or tools are required to connect or disconnect the Victor coupler. While under working pressure, it cannot be uncoupled either accidentally or deliberately. As an additional safety measure, a spring bridle holds the two parts together, and has been designed to allow the stem to rotate within the spud to allow kinks and twists in the hose to be straightened out. The rubber sealing ring is easily replaced when necessary, but since it is completely protected from damage and has a long life, this will not often arise.

The coupler stem is available in three types and the spud fitting in seven types. The range of hose sizes covered is ½-in., ¾-in. and 1-in. diameter, as hose-to-hose coupler or compressor-to-machine coupler.

Diesel-engined "swing shovel" for loading materials from stock-pile to vehicle. It will do light excavating down to 16 in. below ground level and on any face up to the vertical. With the aid of a special bracket the machine can be converted to a mobile crane.

COMMERCIAL VEHICLE SHOW

LIGHT-ALLOY COACHWORK

The 17th International Commercial Motor Transport Exhibition due to open to-day, September 24, at Earls Court, London, will close on October 2. On September 30, a demonstration of military transport-vehicles of various types, built by the motor industry in conjunction with the Fighting Vehicles Research and Development Establishment, is to take place at Chertsey. This event has been arranged jointly by the Ministry of Supply and the Society of Motor Manufacturers and Traders, Limited, of 148 Piccadilly, London, W.1, who are the organisers of the exhibition. The test circuits over which the vehicles will perform simulate the worst possible conditions, and it is hoped in this way to show users from overseas the suitability of certain types of vehicles for operation in areas where roads are virtually non-existent.

Some 424 vehicles will be displayed at Earls Court and the 420 exhibitors will be divided, as in previous years, into the following groups: commercial vehicles; bodywork and trailers; transport service equipment; accessories and components; tyres; and other services. A brief review of trends in the commercial-vehicle industry is given in a Weekly Survey in this issue.

64-SEAT DOUBLE-DECK BUS

A vehicle that will be of particular interest to engineers and the public alike is the prototype of a new bus, for the London Transport Executive, which will eventually replace the existing 70-seater trolley buses. It incorporates a surprising number of departures from commonly accepted practice and will seat 64 passengers within a loaded weight no greater than that of the present 56-seater RT bus, estimated at 11 tons. The saving necessary to achieve this has been made possible by using light alloys, fibre glass and other lightweight materials. Monocoque construction has been used for the body, and ease of servicing, overhaul and control have all been given much attention. The bus is illustrated in Fig. 1 and some points of design in Figs. 2 and 3, opposite.

Small sub-frames which can be removed from the main body carry the mechanical details and the body distributes the load, which is supported by independent front-suspension and a patented form of coil-spring rear-suspension arranged to give a wide roll-centre, stability and improved riding characteristics. In the cab the gear-selector pedal has been eliminated, direct engagement of the gears being by electro-hydraulic means controlled by a column-mounted gear-shift lever. The handbrake is placed at the left of the driving position and improved ventilation, heating as well as de-misting is provided.

As can be seen from the illustration, the body has four bays; these consist of a rigid box formed by the underframe, sides, roof and front and rear bulkheads fabricated from high-duty aluminium alloys. The front bulkhead carries the driver's cab and front nearside body fittings, and the rear platform structure and staircase are suspended from the upper saloon.

The underframe consists of cross bearers of deep section in the form of I-beams with the lower-saloon side pillars bolted to the ends. Stressed panels from waist to skirt are riveted to the inside flange of the pillars and bolted between the crossbearer and pillar. The waist rail and cant rail are channels riveted to the pillars in bay lengths to provide anchorage for the panelling and window pans. The exterior panelling is butt-jointed and blind riveted to the framing without vertical cover strips, the stress panelling being fitted internally to minimise replacement difficulties in the event of damage.

Floor bearers for the intermediate roof extend from pillar to pillar, forming the anchorage for the upper-saloon pillars, and the stress panels of the upper saloon are fitted externally as they are not prone to damage. Sheet aluminium is used for the interior panelling.

The roof structure is of square-section tube with sheet exterior panelling overlapped and riveted in bay lengths from front to rear, and aluminium sheet front and rear domes. The floors and ceilings are made entirely from alloy sheeting; in corrugated form this performs the load-carrying functions and in sheet form provides the ceiling and floor coverings. An interesting feature of the upper-deck floor is that the sheeting is laid in three flats instead of the orthodox radius.

The rear wheelboxes and foot-stools are fabricated in sheet alloy and are made exceedingly rigid, since they form beams supporting the rear-suspension unit. The rear-platform framing is suspended from the upper-saloon rear end, and the platform floor is alloy framed and covered with alloy sheet, suitably stiffened. The rear-end framing extending round the rear quarter and up to cant level is designed to be easily removable in the event of damage. To facilitate working on the rear end the staircase is split at the fourth tread so that the lower portion can be replaced if damaged.

The front bulkhead has a continuous channel member from side to side above the flywheel arch and a skin of aluminium alloy on the forward face to which the channels and angles forming the bulkhead proper are riveted. Two buttresses are built on the front bulkhead on each side of the flywheel arch to form the anchorage for the front sub-frame attachment bolts. The rear anchorages of the front sub-frame are built into the ends of the front cross-bearer and the body-side to carry the horizontally-disposed attachment bolts. Additional alloy-sheet trussing extends forward to the bulkhead and back to the second bearer, to spread the load.

A bonnet top of Fibreglass is hinged to the front bulkhead. The front nearside wing which is of the enveloping type, is suspended from the bulkhead on flexible bushes, and fibre-glass is also used for the wing valances. The frontal grille is in sheet aluminium.

The seating capacity of 64 is disposed so that 28 seats are in the lower saloon and 36 in the upper. The squab backs of the seats are fabricated from Fibreglass, and the cushion and squab fillings, in the interests of lightness, are of a foam plastic.

ENGINE AND FRONT AXLE ASSEMBLY

The engine, steering and front suspension are carried on a sub-frame which consists mainly of two pressed-channel longitudinal members. They extend forward from the front bulkhead and are attached at four points, two at No. 2 cross-bearer and two at buttresses built on the front bulkhead. In plan, the members converge towards the front, being anchored to the main body sides at No. 2 cross-bearer and reduced to normal chassis width at the front.

The longitudinals are joined by two cross-members; a box-section member under the centre of the engine carries the main engine-mountings and the mountings of the independent front-suspension units, while a channel-section member joins the front ends of the longitudinals and supports the front of the engine, as seen in the illustration of the complete vehicle.

At each of the four body-attachment points a large pin or bolt forms the main attachment with a shallow double-conical packing interposed in seatings between the two connected assemblies for location purposes. The two pins at the front bulkhead are vertical, and those at the rear are horizontal.

In order to remove the front assembly, the propeller shaft, controls, fuel and brake lines are disconnected and the pins of the front attachment points are removed. The complete body is then lifted, the front unit hinging about the rear-attachment points until the steering column has cleared the cab floor. The points of attachment are then disconnected and the running unit wheeled forward.

An A.E.C. 9·6-litre direct-injection engine developing 125 brake horse-power is fitted and, because of the absence of a conventional frame and leaf springs, has been mounted offset towards the left-hand side.

The main engine mounting is approximately at the centre of the engine and consists of two rubber-sandwich units positioned to form a "V" about the longitudinal axis of the engine and attached to facings on the crankcase bottom-half. A third mounting point is in the form of a large circular rubber unit on the front of the cylinder block and this is carried on the leading cross member.

The water pump and fan are mounted with the radiator, which is placed at a slight angle beneath the main floor, as shown in the drawing, so that stones thrown up by the wheels do not strike it. This unit is carried by three flexible mountings. The water pump and fan are driven by a duplex chain in an oil-bath casing from a jackshaft connected to the rear of the dynamo. Ducting is provided between the fan and the radiator, and a condensing-type header tank is fitted on the front bulkhead. The filler cap is accessible through a trap which is located in the wing.

Transmission is through a fluid flywheel and independently-mounted epicyclic gearbox having the brake bands operated by direct hydraulic pressure.

Fig. 1 By using light alloys and plastic materials an unladen weight of 6 tons 14 cwt. has been obtained for this 64-seater bus. The body is in the form of a rigid box and the mechanical units are arranged as removable assemblies.

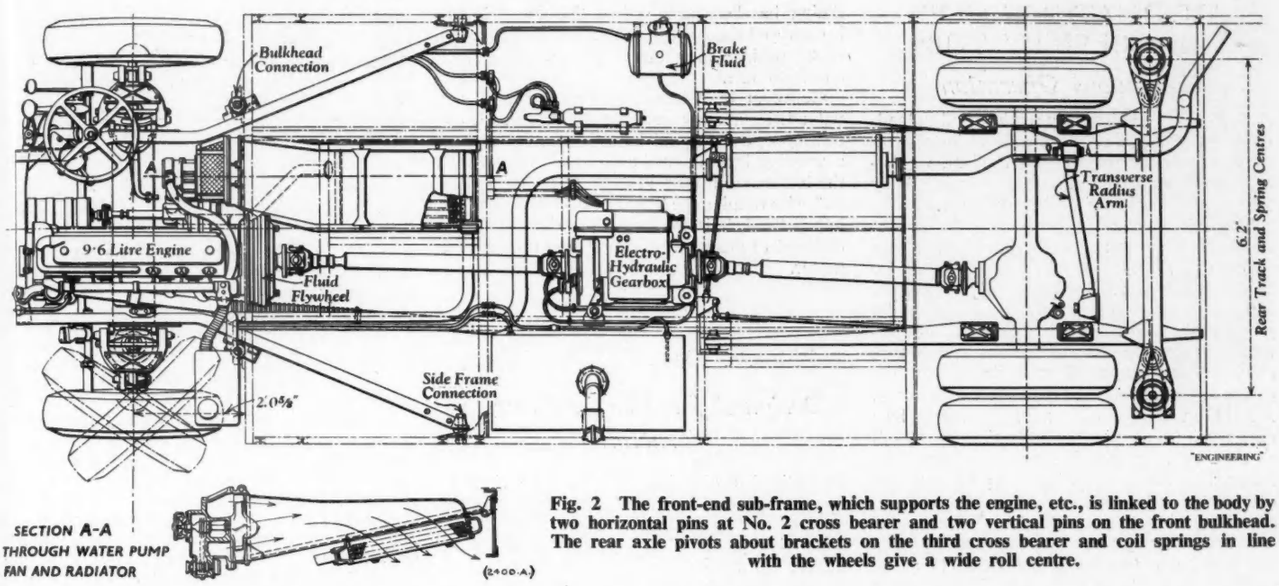


Fig. 2 The front-end sub-frame, which supports the engine, etc., is linked to the body by two horizontal pins at No. 2 cross bearer and two vertical pins on the front bulkhead. The rear axle pivots about brackets on the third cross bearer and coil springs in line with the wheels give a wide roll centre.

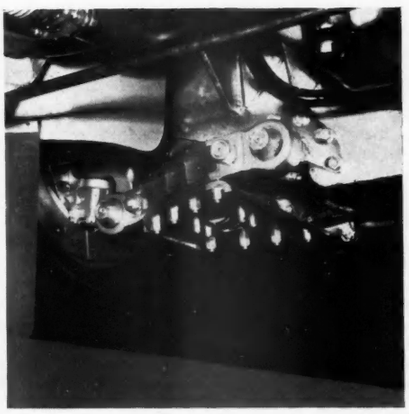


Fig. 3 Underneath view of a front suspension wishbone.

The rear-axle reduction is by spiral bevel gears and the axle shafts are fully floating. The drive unit is offset towards the left hand and the ratio is 5·22 to 1.

REAR SUSPENSION

The main members of the rear suspension are two spectacle radius arms of pressed-channel section. They are pivoted at their front end on rubber bushes from brackets adjacent to the third body-bearer. The rear-axle casing passes through the radius arms and is attached to them by two inclined rubber mountings. The radius arms extend backward and are bolted to an I-section member consisting of two channels back to back which extend across almost the full width of the vehicle behind the rear axle and react at the outer ends against coil springs which are housed in the wheelboxes. Telescopic direct-acting hydraulic dampers are enclosed within the springs and progressive rubber-bump units are provided to prevent sudden shock being transmitted to the main structure. A further light-channel member ties the two radius arms together in front of the axle. Lifting of one wheel only is accommodated by the rubber-bush anchorage and by allowing the suspension members to weave. Lateral location is by a transverse radius rod extending from a bracket on the right-hand end of the axle casing to the left-hand side of the body structure.

Independent front-suspension is used with unequal length wishbones and coil springs, as shown in the illustration. The wishbone units are each pivoted to the main front cross-member, which also carries the engine mounting and the swivel-pin bosses by conical rubber-bush units.

The coil springs are fitted between the lower wishbones and the top of the cross-member with direct-acting telescopic-hydraulic dampers fitted inside the springs. The spring with the damper unit can be removed by undoing eight bolts.

The complete vehicle which is to be known as the Road Master, Type R.M., is 27 ft. long and 8 ft. wide. Its unladen kerb weight is 6 tons 14 cwt. This prototype has been developed and constructed in association with A.E.C., Limited, Southall, and Park Royal Vehicles, Limited, London, N.W.10.

8½-TONS PAYLOAD AT 30 m.p.h.

A flat-platform lorry with forward control having an unladen weight of less than 3 tons and capable of carrying a payload of 8½ tons will be shown by Mann Egerton and Company, Limited, Norwich. Due to the class in which this vehicle is placed it can legally travel at 30 m.p.h. The saving in weight necessary to achieve this has been made possible by using aluminium throughout and welding it by the Argonaut process, except at a few specific points where it was necessary to use Argonarc welding.

Mann Egerton and Company who were responsible for the design and fabrication of the frame and body were assisted throughout by the development department of the British Aluminium Company, Limited, Norfolk House, St. James's-square, London, S.W.1. A 92-h.p. horizontal under-the-floor Diesel engine made by Dennis Brothers, Limited, Guildford, who also supplied the other mechanical components.

Following the exhibition this lorry is to undergo strain-gauge testing at the Motor Industry Research Association's proving ground at Lindley, Nuneaton.

A view of the main member showing the forward bracket for the front spring is in Fig. 4. The two main longitudinal members are of J-section, a ¼ in. thick, slotted to take the angle cross-bearers of ¼-in. thickness. The longitudinals are 13 in. deep. At the forward end they reduce to 8 in. and at the rear the flange is tapered up to the channel-section cross member. Both the cross bearers and longitudinal members were formed from N.S.5 sheet material in a brake press and the top flange of the J-section was welded in position after positioning the cross-bearers. To ensure the correct degree of stiffness eleven full-width cross bearers have been fitted.

The side raves of extruded section are bolted to the outriggers to facilitate replacement if they are damaged in service, and ⅛-in. thick P-G-P light-pattern tread-plate flooring is riveted to the cross bearers for the same reason. Aluminium spring hangers are provided at the spring shackles. The rear-spring brackets are of the standard Dennis Centaur steel-type bolted to the longitudinals through the medium of thick doubling plates. The engine is flexibly suspended by two steel brackets and one aluminium.

The headboard is framed in aluminium-alloy angle section and the sheeting is of 14-s.w.g. alloy riveted to the frame. A modern-styled cab of full width is fitted and the frame work consists of welded sections. At the front of the cab, on the inside, a crash plate of 16 s.w.g. is provided. The outer panelling of the cab is of embossed 20-s.w.g. sheet unpainted. The moulding strips and bumper have been made from a special bright-finished aluminium. Four Metacone mountings support the cab, and the front and rear wings are made from 16-s.w.g. sheet. The vacuum tank and fuel tank have also been constructed from aluminium sheet.

To be continued

Fig. 4 Aluminium plates welded to main chassis J-section members to carry the springs.

AUTOMATIC TIPPLER FOR COLLIERY TUBS

Continuous Operation

A tippler that continuously receives and unloads colliery tubs automatically has been installed at the surface of the Babbington Colliery, Cinderhill, Nottingham. It has been designed by Mr. H. Horrocks, the colliery manager.

The full tubs, after being brought to the surface, travel over rails through a small storage siding, past a control point and the weighbridge to arrive before the tippler; at this point the tubs are running on a down gradient under gravity. As may be seen from the first illustration the rails stop short of the tippler and tubs come under the control of chain feeders, the chains engaging with and carrying the tub axles. A full tub waiting to enter the feeder is held by a drop catch (shown, in the illustration, depressed) so that the front axle is supported clear of the feeders; on being released the drop catch allows the front axle to engage with the feeder chains and the tub is drawn towards the tippler. As it is carried along the feeder, the front axle operates two arms, one tripping a star catch to allow another full tub to take up its position and the other re-setting the drop catch.

The tippler itself is controlled by three valves mounted on pillars at the ends of the tippler and operated by roller-tipped levers engaging with the tub sides. One of these valves, at the "empty" end of the tippler, shown in the second illustration, is the main operating valve; the other two, one at each end of the tippler, are in-line valves which ensure that rotation of the tippler is prevented if a tub is not correctly located within the frame.

As the full tub enters the tippler, it depresses the arm of the "full" end in-line valve, while at the same time the then empty tub is pushed out of the tippler depressing the arms of the operating valve and the second in-line valve simultaneously. The operating valve then admits air to the operating circuit but this remains broken until the empty tub clears the arm of the in-line valve; as soon as this arm is free it springs back (and as long as the full-end valve is clear) the tippler operates.

As the tippler rotates, a lug on the end ring of the frame re-sets the operating valve, and another lug at the other end strikes a lever on the release valve of the drop-catch so allowing the next full tub to engage with the feeder. The timing has been arranged so that the full tub is conveyed the length of the feeder and is ready to be pushed into the tippler as the latter comes to rest.

Conveyor belts below the tippler receive the unloaded coal and carry it to the screens. If the belt stops, a red signal light is illuminated and a warning bell sounded and an attendant stops the feeder and tippler motors by an emergency pull-wire running the length of the tippler gantry. When the belt is re-started, the signal lamp is changed to green and the attendant re-starts the motor.

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25-H.P. DIESEL ENGINE

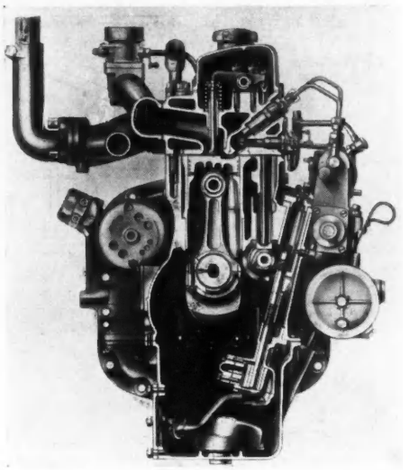
Designed for Use in Crawler Tractors

The Diesel engine illustrated on the right is now being fitted in the Model 25 CI crawler tractor made, by F.A. FIAT, of Turin, Italy, in place of a petrol-paraffin type engine. As a result it will have a higher power to weight ratio and be suitable for more arduous duties. The distributor of this tractor in Britain is Mackay Industrial Equipment, Limited, Faggs-road, Feltham, Middlesex.

The new engine develops 25 h.p. at 2,000 r.p.m. and operates on a four-stroke cycle. It has four cylinders, a bore of 3·22 in. and a stroke of 3·54 in. The capacity is 1,901 c.c. and the compression ratio 20 to 1. It is said that particularly smooth running has been obtained by using the Ricardo-Comet pre-combustion chamber with the injectors and valves positioned as shown in the illustration. The specific fuel consumption is also said to be low, being 0·42 lb. per brake horse-power hour.

Overhead valves, one exhaust and one inlet, and rocker gear have been fitted. They are operated through push rods by a camshaft which is mounted in three bearings and is driven by helical gears at the front of the engine. The fuel-injection pump is of the Bosch type and was also made by the Fiat Company. It gives an injection pressure of 1,850 lb. per square inch and has a vacuum governor.

The pintle injectors are set in recesses in the cylinder head, which is a one-piece casting incorporating four combustion chambers and carries the valves. The cylinder block and crankcase are also cast in one and replaceable wet liners are used.



The cylinder head of this 25-h.p. Diesel engine incorporates a Ricardo-Comet combustion chamber into which the fuel is injected through a pintle nozzle. Next to it a heater plug is mounted to assist cold starting.

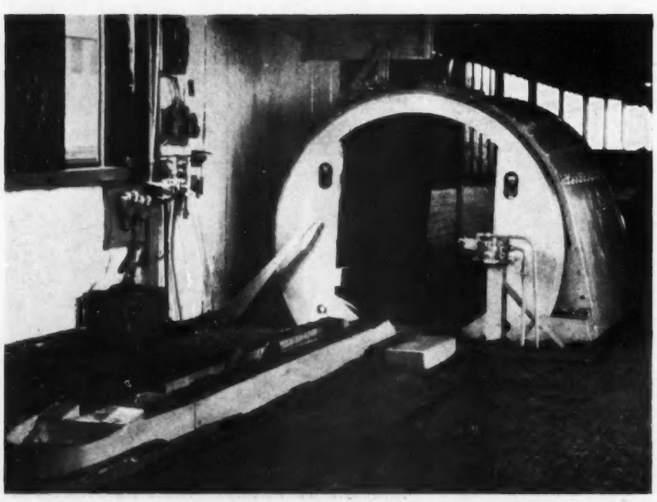
A submerged pump circulates the oil and a pressure-relief valve, fitted in an accessible position, enables some adjustment of the pressure to be made. The capacity of the system is 11·8 pints.

The combined fan and water-circulating pump, mounted on the front of the cylinder head, is driven by a V-belt from the crankshaft. The temperature of the water is controlled by a thermostat in the outlet from the cylinder head.

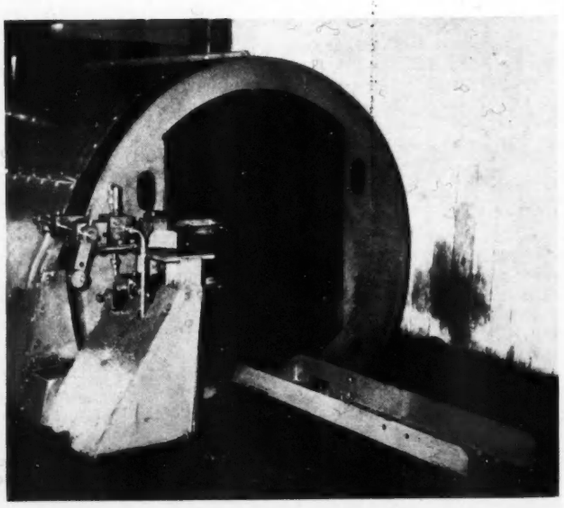
Preheater plugs are fitted in the cylinder head to assist starting which is by a 24-volt electric motor.

The engine develops a belt horse-power of 24 and a drawbar horse-power of 20. The following table shows the speeds and draw-bar pulls which can be obtained:—

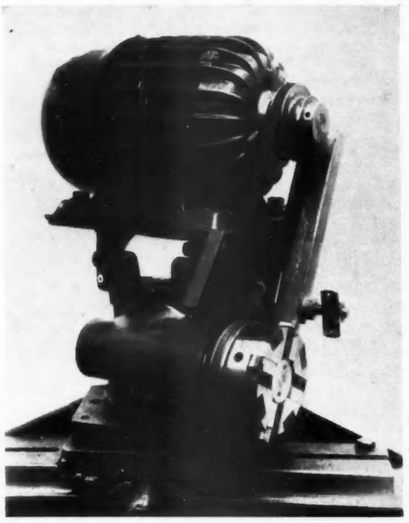
Gear	Speed, m.p.h.	Pull, lb.
First	1·1	4,500
Second	1·6	4,150
Third	2·0	3,750
Fourth	4·5	1,725
Reverse	1·1	—



The "full" end of the tippler, showing the chain feeder with the drop-catch (here depressed) and the trip arms.



The "empty" end of the tippler; the two lever arms control the in-line valve and the main operating valve.



The 9-lb. cutter head serves as a flywheel assisting smooth operation. Four cutters are carried in either the axial slots or radial slots.

MILLING ATTACHMENT

Head with Four Fly-cutters

The universal milling attachment shown in the accompanying illustration is made in Austria and has been introduced to this country by Herbert Bennett, Limited, 3a Wood-street, London, E.C.2. It is known as UFK Mark 4, and is suitable for milling threads, cutting keyways and plain and end milling.

On the standard version the cutter is driven by a V-belt from a two-step pulley mounted on the shaft of a 950-r.p.m. 1½-h.p. motor, giving cutting speeds of 970 r.p.m. and 475 r.p.m. Alternatively, a pulley can be fitted which gives a range of five cutting speeds from 270 to 1,900 r.p.m. The guard which covers the belt has been removed from the machine in the illustration for clarity.

The cutter head measures 118 mm. in diameter and has four radial and four axial slots for carrying carbide-tipped fly-cutters. It is mounted on a spindle running in taper roller bearings. The head and its pulley weigh 9 lb. and serve as a flywheel storing sufficient energy to ensure a smooth cutting operation. The spindle has been bored for a screw and nut that draws the cutter head on to a ground cone and is also made with part of the bore ground and hardened to take a No. 3 Morse taper shank. This enables drills, grinding-wheel arbors with wheels up to 8 in. diameter and internal thread-milling tools to be carried.

To facilitate positioning of the cutter head a pivot point has been incorporated which gives 360 deg. of movement in the horizontal plane. In the vertical plane of cutter rotation, 15 deg. tilt up or down can be obtained and the spindle axis can also be dipped 15 deg. or raised 100 deg. in the vertical plane.

The baseplate, which measures 200 mm. by 260 mm., is laid out for assembly on the cross-slide of most lathes with 4 in. or more centre height. Alternatively, it can be arranged to fit on the compound slide. In the case of milling machines it is normally attached to the vertical column. The overall height of the complete attachment is 19 in. and it weighs 146½ lb. The maximum cut that can be taken is 0·010 in.

Two larger versions of this machine, models numbered UGS-8 and UGS-12, have also been introduced by the company.

C_0-C_0 ELECTRIC LOCOMOTIVES FOR MANCHESTER-SHEFFIELD LINE

Maximum speed 90 m.p.h.

The passenger services on the newly electrified line between Sheffield (Victoria) and Manchester (London Road) which were inaugurated on September 14 (see Weekly Survey in this issue) will be hauled by seven electric locomotives, built jointly by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, and British Railways. These locomotives, one of which is illustrated in Fig. 1, are somewhat similar to those already described (ENGINEERING, vol. 173, page 321, 1952), but have a C_0-C_0 wheel arrangement instead of B_0-B_0 and a maximum service speed of 90 m.p.h. Their overall length is 59 feet and total weight 102 tons. The six driving motors give a total horse power at the one-hour rating of 2,760, but the nominal tractive effort of 45,000 lb. is the same as the B_0-B_0 locomotives. As the maximum speed for which the present tracks are suitable is only 65 m.p.h., these locomotives cannot be run at their maximum; the high speed is intended to take advantage of any extensions to the electrification scheme which might be made in the future.

As with the B_0-B_0 type, they were constructed for one-man operation; Fig. 2 shows the cab arrangements. At present, however, two-man operation is the rule.

The electrical equipment, with the exception of the main motor and some of the switchgear, is very similar on the two classes of locomotive. The main switchgear is of the electro-pneumatic type consisting of unit switches, and drum-type grouped switches, operated from the master controllers. These and other items of equipment are housed in the high-tension compartment in removable frames for easy installation or removal for repair. These master controllers have four handles, a removable "forward" and "reverse" key, an accelerating lever which progressively notches through all three motor combinations, and a regenerative and weak field lever for varying the amount of regeneration by altering the excitation of the traction motor fields. This lever, in the opposite direction of motion, enables three steps of weak field to be obtained on the motors while taking power. A fourth lever, on the extreme right of the controller, selects the motor combination in regeneration. All levers are suitably interlocked to prevent improper use, the controller being mounted on the driver's right. Since the locomotives are designed for one-man operation, a pedal acts as the "dead-man" safety control. This has a delayed action of 6 seconds, after which power is cut off and the brakes applied. Air brakes are fitted on the locomotives in addition to the regenerative braking system, and provision has also been made for vacuum brakes on the train.

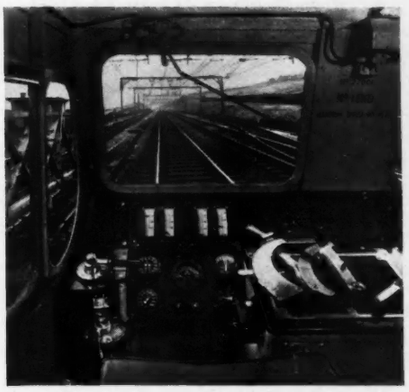


Fig. 2 Driver's cab of a C_0-C_0 locomotive; controls have been arranged for one-man operation.

The traction motors are of the axle-hung series-wound type, one on each axle. Auxiliary machines provide such services as compressed air for operation of the locomotive air brake and the main switchgear, and include a vacuum exhauster for the brakes on the train as well as two motor generator sets one for the low tension control and the other for the excitation of the traction motors during regeneration. These sets are also equipped with blowers for supplying forced ventilation to the traction motors. An electric boiler provides steam heating services to passenger trains in the winter.

A structural difference between the B_0-B_0 and C_0-C_0 locomotives is that while in the former the buffing and drawgear is mounted on the bogie frame, in the latter it is mounted direct on the understructure and the bogies are completely independent except through the connections to the main frames.

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1956 MACHINE TOOL EXHIBITION

London has been chosen as the venue for the next International Machine Tool Exhibition. It will be the major machine-tool exhibition for the year 1956, and will be held at Olympia from Friday, June 15, to Friday, June 29.

With the object of preventing overlapping, an understanding has been reached with the European Committee for the Co-operation of Machine Tool Industries that no other international machine-tool exhibition shall be held in Europe during 1956.

The exhibition will be organised by the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1, and the Association will be assisted by a committee of representative members of the industry, of which Mr. H. P. Potts, a director of B.S.A. Tools, Ltd., Birmingham, will be chairman.

Fig. 1 C_0-C_0 locomotive of 2,760 h.p. for express-passenger and mixed-traffic work. These have been designed to meet the likely needs of extensions.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. An asterisk(*) indicates events appearing in the list for the first time. Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *August* 27, *page* 281. *Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

INTERNATIONAL COMMERCIAL MOTOR TRANSPORT EXHIBITION.—Fri., Sept. 24, to Sat., Oct. 2, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

METZ INTERNATIONAL TRADE FAIR.—Sat., Sept. 25, to Mon., Oct. 11. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

GERMAN INDUSTRIES EXHIBITION.—Sat., Sept. 25, to Sun., Oct. 10, at Berlin. *Agents:* Gardiner Travel Service, 189 Regent-street, London, W.1. Tel. REGent 1416.

BUSINESS EFFICIENCY EXHIBITION.—Mon., Sept. 27, to Sat., Oct. 2, at the City Hall, Manchester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

INTERNATIONAL ENGINEERING FAIR.—Wed., Sept. 29, to Sun., Oct. 10, at Turin. Apply to the exhibition secretary, Via Massena 20, Turin; or to Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

RADIO, TELEVISION AND ELECTRONICS EXHIBITION.—Sat., Oct. 2, to Sun., Oct. 10, in Paris. Organised by the Salon de la Radio, de la Télévision et de l'Electronique, 23 Rue de Lubeck, Paris, 16e.

BREWERS' EXHIBITION.—Mon., Oct. 4, to Fri., Oct. 8, at Olympia, London, W.14. Apply to Trades Markets and Exhibitions Ltd., 623 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 1371.

INTERNATIONAL PLASTICS EXHIBITION.—Tues., Oct. 5, to Sun., Oct. 17, at Oslo. Organised by the Forening for Norsk Plastindustri, 53B Munkedamsveien, Oslo.

*SULPHUR REMOVAL AND RECOVERY FROM FUELS, CONFERENCE.—Wed. and Thurs., Oct. 6 and 7, at the Institution of Mechanical Engineers, 1 Birdcage-walk, London, S.W.1. Organised by the Institute of Fuel, 18 Devonshire-street, London, W.1. Tel. LANgham 7124. See ENGINEERING, August 27, page 278.

INTERNATIONAL MOTOR CAR, CYCLE AND SPORTS EXHIBITION (41ST).—Thurs., Oct. 7, to Sun., Oct. 17, in Paris. Organised by the Chambre Syndicat des Constructeurs d'Automobile Grand Palais, 111 Avenue Alexandre, Paris, 8e. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

NATIONAL CHEMICAL EXPOSITION (EIGHTH).—Tues., Oct. 12, to Fri., Oct. 15, at the Coliseum, Chicago. Manager: Mr. James J. Doheny, 86 East Randolph-street, Chicago, Illinois, U.S.A.

ENGINEERING INDUSTRIES ASSOCIATION: LONDON REGIONAL DISPLAY.—Tues., Oct. 12, to Thurs., Oct. 14, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Assocation, 9 Seymour-street, Portman-square, London, W.1. Tel. WELbeck 2241.

CATALOGUE EXHIBITION.—Tues., Oct. 12, to Sat., Oct. 23, at the British Institute of Management, 2 Hill-street, London, W.1. Organised by the British Federation of Master Printers, 11 Bedford-row, London, W.C.1. Tel. CHAncery 6904.

BUSINESS MACHINES AND OFFICE EQUIPMENT EXHIBITION.—Wed., Oct. 13, to Sun., Oct. 24, in Paris. Organised by the Salon International de l'Equipement de Bureau, 6 Place de Valois, Paris, 1er.

*PLASTIC TOOLING CONFERENCE.—Thurs. and Fri., Oct. 14 and 15, at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Sheet and Strip Metal Users' Technical Association, 49 Wellington-street, London, W.C.2. Tel. TEMple Bar 3951.

BUILDING TRADES EXHIBITION.—Tues., Oct. 19, to Sat., Oct. 30, at Manchester. Apply to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

BUSINESS EFFICIENCY EXHIBITION.—Tues., Oct. 19, to Fri., Oct. 22, at Waverley Market, Edinburgh. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

INTERNATIONAL MOTOR EXHIBITION.—Wed., Oct. 20, to Sat., Oct. 30, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

"VOCHEMA" INTERNATIONAL MACHINERY AND APPARATUS EXHIBITION FOR THE FOOD PROCESSING, CHEMICAL AND PHARMACEUTICAL INDUSTRIES.—Wed., Oct. 20, to Wed., Oct. 27, in the Bernhard Hall, Croeselaan site, Utrecht, Holland. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

BRITISH TRADE FAIR, BAGHDAD.—Mon., Oct. 25, to Mon., Nov. 8, at Baghdad, Iraq. Organised, at the invitation of H.M. Government, by British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See ENGINEERING, January 29, page 135.

NATIONAL METAL EXPOSITION (36TH).—Mon., Nov. 1, to Mon., Nov. 15, at Chicago. Organised by the American Society for Metals. Communications to Mr. W. H. Eisenman, secretary of the Society, 7301 Euclid-avenue, Cleveland, Ohio, U.S.A.

BRITISH OCCUPATIONAL HYGIENE SOCIETY'S CONFERENCE.—Mon., Nov. 1. at London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Apply to Dr. C. N. Davies.

*BOTTLING EXHIBITION (NINTH INTERNATIONAL).—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. *Agents:* General-Tours Agence Generale de Tourisme (U.K.), Ltd., 25 and 26 Park-lane, London, W.1. Tel. HYDe Park 6854.

INTERNATIONAL CLOTHING AND MATERIAL INDUSTRIES EQUIPMENT EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Apply to the exhibition offices, 40 Rue du Colisée, Paris, 8e.

DAIRY EQUIPMENT EXHIBITION (SECOND).—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de l'Equipement Laitier, 28 Rue Louis le Grand, Paris, 2e.

FOOD INDUSTRIES AND TRADES EQUIPMENT EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de l'Equipement des Industries et des Commerces de l'Alimentation, 42 Rue du Louvre, Paris, ler. *Agents:* General-Tours Agence Generale de Tourisme (U.K.), Ltd., 25 and 26 Park-lane, London, W.1. Tel. HYDe Park 6854.

MECHANICAL HANDLING EXHIBITION.—Wed., Nov. 3, to Thurs., Nov. 11, in Paris. Organised by the Salon de la Manutention, 40 Rue du Colisée, Paris, 8e.

SAFETY IN CHEMICAL WORKS.—Fri., Nov. 5, to Sun., Nov. 7, at Harrogate. Conference organised by the Association of British Chemical Manufacturers, 86 Strand, London, W.C.2. Tel. COVent Garden 2363.

INDUSTRIAL TOOL AND EQUIPMENT SHOW.—Mon., Nov. 8, to Fri., Nov. 12, at the Show Mart Building, Montreal. Held in conjunction with the Montreal Materials Handling Show. *Agents*: John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

CYCLE AND MOTOR CYCLE SHOW.—Sat., Nov. 13, to Sat., Nov. 20, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., Warwick-road, Coventry. Tel. Coventry 62511.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION.—Mon., Nov. 15, to Sat., Nov. 20, at Olympia, London, W.14. Organised by The Municipal Agency, Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132. See page 403.

*"ELECTRONICS AT WORK."—Tues., Wed. and Thurs., Nov. 23, 24 and 25, at the Chamber of Commerce Hall, Birmingham. Organised by the Electrical and Electronics Group of the Scientific Instrument Manufacturers' Association of Great Britain, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251.

X-RAY APPARATUS EXHIBITION.—Tues., Nov. 23, to Fri., Nov. 26, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised in conjunction with the congress of the British Institute of Radiology, 32 Welbeck-street, London, W.1. Apply to Mr. A. Beetlestone, Mullard, Ltd., New-road, Mitcham Junction, Surrey. Tel. Mitcham 2071.

INTERNATIONAL CYCLE AND MOTOR-CYCLE EXHIBITION (32ND).—Sat., Nov. 27, to Wed., Dec. 8, in the Mechanical Engineering Pavilion, Milan Fair site, Milan. Organised by the Italian Association of Manufacturers of Cycles, Motor Cycles and Accessories, 32 Via Mauro Macchi, Milan.

INTERNATIONAL "AUTOMATION" EXHIBITION.—Mon., Nov. 29, to Thurs., Dec. 2, at 242nd Coast Artillery Armory, 14th-street off Sixth-avenue, New York. Apply to Mr. Richard Rimbach, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

POWDER METALLURGY SYMPOSIUM AND EXHIBITION.—Wed. and Thurs., Dec. 1 and 2, at Church House, Great Smith-street, London, S.W.1. Organised by the Iron and Steel Institute and the Institute of Metals. Apply to the secretary, Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061. See ENGINEERING, April 23, page 518.

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.—Mon., Dec. 6, to Fri., Dec. 10, at Earl's Court, London, S.W.5. Inquiries to the exhibition manager, Smithfield Show, 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

PACKAGING EXHIBITION, FOURTH INTERNATIONAL.—Tues., Jan. 18, to Fri., Jan. 28, 1955, at Olympia, London, W.14. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

BUSINESS EFFICIENCY EXHIBITION.—Tues., Feb. 8, to Fri., Feb. 11, 1955, at the Granby Halls, Leicester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

FACTORY EQUIPMENT EXHIBITION (THIRD).—Mon., Mar. 28, to Sat., April 2, 1955, at Earl's Court, London, S.W.5. Apply to Mr. J. E. Holdsworth, 117 Kingsway, London, W.C.2. Tel. CHAncery 2318.

PHYSICAL SOCIETY'S EXHIBITION OF SCIENTIFIC INSTRUMENTS AND APPARATUS (39TH).—Mon., April 25, to Thurs., April 28, 1955, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. Tel. KEN[illegible]ton 0048.

*BRITISH [illegible]USTRIES FAIR.—Mon., May 2, to Fri., May 13, 1955, at Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars from British Industries Fair Ltd., Ingersoll House, 9 Kingsway, London, W.C.2. Tel. COVent Garden 1461; or from the general manager, British Industries Fair, 95 New-street, Birmingham, 2. Tel. Midland 5021.

*NEW YORK TRADE FAIR.—Sun., May 15, to Thurs., May 19, 1955, at the Armory, 25th-street, Manhattan, New York. Organised by International Trade Shows, 545 Fifth-avenue, New York.

*INTERNAL COMBUSTION ENGINE CONGRESS, INTERNATIONAL.—"COLLOQUY 1955—THE HAGUE."—Mon., May 23, to Sat., May 28, 1955, at Scheveningen, Holland. Organised by the Congrès International des Moteurs a Combustion Interne, 11 Avenue Hoche, Paris, 8e. Inquiries in Britain may be sent to the British Internal Combustion Engine Research Association, 111-112 Buckingham-avenue, Slough, Buckinghamshire. Tel. Slough 20295. See ENGINEERING, July 16, page 72.

*CANADIAN INTERNATIONAL TRADE FAIR (EIGHTH).—Mon., May 30, to Fri., June 10, 1955, at Toronto. Further information from Miss M. A. Armstrong, Canadian Government Exhibition Commission, Canada House, Trafalgar-square, London, S.W.1. Tel. WHItehall 8701.

*BRITISH INSTRUMENT INDUSTRIES EXHIBITION.—Tues., June 28, to Sat., July 9, 1955, at Earl's Court, London, S.W.5. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

*CONFERENCE ON COMBUSTION.—Wed., Thurs. and Fri., June 15, 16 and 17, 1955, at Cambridge, Mass., U.S.A.; and Tues., Wed. and Thurs., Oct. 25, 26 and 27, 1955, in London. See page 398.

*SAFETY AND FACTORY EFFICIENCY EXHIBITION.—Fri., June 24, to Fri., July 1, 1955, at Bingley Hall, Birmingham. Information from the Industrial Safety Training Centre, Museum of Science and Industry, Newhall-street, Birmingham, 3.

ENGINEERING, MARINE, WELDING AND FOUNDRY TRADES EXHIBITION (20TH).—Thurs., Sept. 1, to Thurs., Sept. 15, 1955, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, London, W.C.2. Tel. WHItehall 0568.

*ALL-BRITISH TRADE FAIR.—Thurs., Sept. 29, to Sun., Oct. 16, 1955, in the Tivoli Gardens and the Forum, Copenhagen, Demark. Inquiries to the British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See ENGINEERING, July 16, page 69.

*GERMAN PLASTICS INDUSTRY.—Sat., Oct. 8, to Sun., Oct. 16, 1955, at Düsseldorf, Germany. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

BOURNEMOUTH
"Electrical Control Gear for Mechanical Handling Plant," by S. H. Harding. Bournemouth Branch. Grand Hotel, Bournemouth. Mon., Sept. 27, 8.15 p.m.
LIVERPOOL
"Off-Peak Space Heating," by C. J. Wheeler. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool, 2. Fri., Oct. 1, 7.30 p.m.
WEMBLEY
"Modern Electric Repair Shop Practice," by E. H. Hymas. North-West London Branch. Century Hotel, Forty-avenue, Wembley Park, Middlesex. Fri., Oct. 1, 8.15 p.m.

British Institution of Radio Engineers

LONDON
"Computing Circuits in Flight Simulators," by Dr. A. E. Cutler. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Sept. 29, 6.30 p.m.
CARDIFF
"Design of Switching Circuits," by Professor Emrys Williams. Annual General Meeting. South Wales Section. Cardiff College of Technology, Cathays Park, Cardiff. Wed., Oct. 6, 6.30 p.m.
GLASGOW
Debate on "Does Industry Want Electronics?" Annual General Meeting. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 7, 6.30 p.m.
LIVERPOOL
"Liverpool University Cyclotron," by M. J. Moore. Followed by visit of inspection. Merseyside Section. Liverpool University Buildings, Liverpool, 1. Thurs., Oct. 7, 7 p.m.

Chemical Society

NOTTINGHAM
"Direct Hydroxylation of Organic Compounds," by Professor W. Bradley. The University, Nottingham. Thurs., Oct. 14, 4.45 p.m.

Engineers' Guild

LONDON
Annual General Meeting. Metropolitan Branch. Caxton Hall, Victoria-street, Westminster, S.W.1. Thurs., Sept. 30, 6 p.m.

Incorporated Plant Engineers

LONDON
"Controlled Air Conditions in Factories," by D. J. Hyam. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 5, 7 p.m.
DUNDEE
Film: "Materials Handling." Dundee Branch. Mathers Hotel, Dundee. Mon., Oct. 11, 7.30 p.m.

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P. & O. LINER IBERIA

Maiden Voyage of the Arcadia's Sister-ship

The twin-screw passenger and cargo liner Iberia, which on Sunday, September 12, completed her trials, having achieved a speed of 24·9 knots on the measured mile, is on Tuesday, September 28, to set out on her maiden voyage to Sydney, New South Wales. The Iberia, which has a displacement of 29,600 tons gross, is in most major respects identical with her sister-ship, the Arcadia, a detailed description of which was given in ENGINEERING (vol. 177, pages 474 and 662) this year, but in appearance is distinguished from the Arcadia by her funnel, the top of which has been specially designed to throw smoke clear of the vessel's superstructure. Built by Harland and Wolff Limited, Belfast, for the Peninsular and Oriental Steam Navigation Company, the Iberia is driven by double-reduction geared steam turbines taking steam from water-tube boilers, and has a service speed of 22½ knots. Berths are provided for 674 first-class and 733 tourist-class passengers, and the space available for cargo is 304,930 cub. ft., of which 147,750 cub. ft. are insulated.

Like the Arcadia, the Iberia is fitted with Denny-Brown stabilisers. The ship's main propulsion units, which are Pametrada-pattern steam turbines, were constructed by the shipbuilders and develop a total of 34,000 shaft horse-power, with an overload rating of 42,500 shaft horse-power.

Although the Iberia and the Arcadia are alike in the size and disposition of their corresponding public rooms, a different style of furnishing and decoration has been adopted in each case. A reserved but colourful contemporary character has been adopted in the Iberia and contrasting fabrics and the use of light woods has introduced a spacious and restful appearance. Of special interest are two excellent tapestries by Dom Robert, a Benedictine monk, and some pleasing murals by Kenneth Rountree and David Lewis. Most unusual of the public rooms is an observation lounge of semi-elliptical shape, in which is situated a large chart table together with a repeater compass, so that passengers may follow the vessel's progress.

EDINBURGH
"Trends in Industrial Instrumentation," by A. B. Dryburgh. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Oct. 5, 7 p.m.
PETERBOROUGH
"Plant Maintenance and Productivity," by R. A. Rogers. Peterborough Branch. Dujon Café, Market-place, Peterborough. Thurs., Oct. 7, 7.30 p.m.
SHEFFIELD
Brains Trust Meeting on "Fuel Conservation" under the chairmanship of Sir Oliver Lyle, O.B.E. Sheffield Branch. Grand Hotel, Sheffield. Thurs, Sept. 30, 7.30 p.m.
SOUTHAMPTON
"The Control of Maximum Demand and Power Factor," by A. W. Ingram. Southampton Branch. Polygon Hotel, Southampton. Wed., Oct. 6, 7.30 p.m.

Institute of British Foundrymen

LONDON
"The Casting of an Aluminium Wheel," by J. R. Harrison, with film. London Branch. Waldorf Hotel, Aldwych, W.C.2. Wed., Sept. 29, 7.30 p.m.
ACCRINGTON
"Production of Woodworking-Machinery Castings," by R. Higgins. Burnley Section. Accrington Grammar School, Blackburn-road, Accrington. Wed., Oct. 6, 7.30 p.m.
CARDIFF
"Aspects of Shell-Moulding Technique," by D. F. Bailey. Wales and Monmouthshire Branch. Engineers' Club, Cardiff. Sat., Oct. 2, 6 p.m.
MANCHESTER
"Semi-Continuous Casting of Bronze," by Dr. E. C. Elwood. Lancashire Branch. Engineers' Club, Albert-square, Manchester. Sat., Oct. 2, 2.30 p.m.
SHEFFIELD
"Science Hand-in-Hand with Labour," by E. Ayres. Presidential Address. Sheffield Branch. Sheffield and Eccleshall Co-operative Society's Restaurant, Sheffield. Mon., Oct. 4, 7.15 p.m.
SLOUGH
"Aluminium Pattern Equipment," by D. H. Potts, with film. Slough Section. Offices, High Duty Alloys, Ltd., Slough. Tues., Oct. 5, 7.30 p.m.

Institute of Fuel

CARDIFF
"Preparation of Water for Use in Steam Boilers," by W. F. Gerard. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Oct. 1, 6 p.m.
EDINBURGH
"Desulphurization of Coke-Oven Gas by Selective Quick Washing with Ammonia Solution and the Conversion of Hydrogen Sulphide to Sulphur, Sulphuric Acid or Ammonium Sulphate," by Dr. H. Bähr. Scottish Section. Joint Meeting with the Institute of Petroleum. North British Hotel, Edinburgh. Fri., Oct. 8, 7 p.m.
LEEDS
Chairman's Address, by S. J. Eardley. Yorkshire Section. Hotel Metropole, Leeds. Wed., Oct. 6, 2.30 p.m.
MIDDLESBROUGH
"Oil-Firing of Open-Hearth Steel Furnaces," by T. Chippindale and A. B. Pritchard. North-Eastern Section. Cleveland Institute, Middlesbrough. Mon., Oct. 11, 6.30 p.m.

Institute of Marine Engineers

LONDON
Presidential Address, by H. A. J. Silley. Tues., Sept. 28, 5.30 p.m.
"Some Fuel-Injection Problems," by Dr. W. P. Mansfield. Tues., Oct. 12, 5.30 p.m.

Institute of Petroleum

EDINBURGH
"Desulphurization of Coke-Oven Gas by Selective Quick Washing with Ammonia Solution and the Conversion of Hydrogen Sulphide to Sulphur, Sulphuric Acid or Ammonium Sulphate," by Dr. H. Bähr. Joint Meeting with the Institute of Fuel. North British Hotel, Edinburgh. Fri., Oct. 8, 7 p.m.

Institute of Road Transport Engineers

LONDON
Annual General Meeting and Film Display. Royal Society of Arts, John Adam-street, Adelphi, W.C. 2. Thurs., Oct. 7, 6.30 p.m.
CAMBRIDGE
"Heavy-Duty Batteries for Commercial and Public-Service Vehicles," by C. P. Lockton. Eastern Centre. Lion Hotel, Cambridge. Wed., Oct. 6, 7 p.m.
GLASGOW
"The Design of Automotive Piston and Ring Assemblies," by L. Howell. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Oct. 4, 7.30 p.m.
NOTTINGHAM
"Paint-Synthetic Resin Finishes and Wet-on-Wet Spraying," by C. Butler. East Midlands Centre. Mechanics' Institute, Nottingham. Thurs., Oct. 7, 7.30 p.m.
PRESTON
"Post-War Development in Brake Linings," by P. Tonge and M. Healey. North-West Centre. Victoria Station Hotel, Preston. Tues., Oct. 5, 7.30 p.m.

Institution of Electrical Engineers

LONDON
Presidential Address by J. Eccles. Thurs., Oct. 7, 5.30 p.m.
BIRMINGHAM
Chairman's Address by A. R. Blandford. Annual General Meeting and Conversazione. South Midland Centre. James Watt Memorial Institute, Birmingham. Mon., Oct. 4, 6 p.m.
BRISTOL
Chairman's Address by A. N. Irens. Western Centre. Offices of the South-Western Electricity Board, Colston-avenue, Bristol. Mon., Oct. 4, 6 p.m.
LEEDS
Chairman's Address by W. A. Crocker. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Oct. 5, 6.30 p.m.
MANCHESTER
Chairman's Address by Professor E. Bradshaw. North-Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Oct. 5, 6.30 p.m.
PORTSMOUTH
Chairman's Address by E. A. Logan. Southern Centre. College of Technology, Portsmouth. Wed., Oct. 6, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Presidential Address by Professor A. M. Robb. Tues., Oct. 5, 7.30 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Engineering Costing and Estimating," by W. S. Shield. North-East Branch. 6 Higham-place, Newcastle-upon-Tyne. Mon., Oct. 4, 7.15 p.m.

Institution of Mechanical Engineers

BRIGHTON
"Patents for Inventions," by Major R. E. Tree. Southern Branch. Brighton Technical College, Brighton. Wed., Oct. 6, 7 p.m.
GLASGOW
"Nuclear Reactors and Power Production," by Sir Christopher Hinton. James Clayton Lecture. Scottish Branch. Royal Technical College, Glasgow. Thurs., Oct. 7, 7.30 p.m.
LEICESTER
"Creative Engineering," by J. H. R. Nixon, branch chairman. East Midlands Branch. Grand Hotel, Leicester. Thurs., Sept. 30, 6.30 p.m.
MANCHESTER
"Practical Training in Industry for the Graduate in Mechanical Engineering," by Kenneth R. Evans, H. W. Fulton, R. S. Medlock, D. P. Lant, and Professor J. A. Pope. North-Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 7, 6.45 p.m.
SWANSEA
Chairman's Address by Professor L. J. Kastner. South Wales Branch. Mackworth Hotel, Swansea. Tues, Oct. 5, 6 p.m.

Institution of Naval Architects and Institute of Marine Engineers

SOUTHAMPTON
"Ministry of Transport Construction Rules," by H. E. Steel. Southampton Technical College, St. Mary-street, Southampton. Tues., Sept. 28, 7.30 p.m.

Institution of Production Engineers

BIRMINGHAM
"The Fawley Experiment: A Report on the Construction of Esso Refinery," by Mark Abrams. Birmingham Section. College of Technology, Birmingham. Wed., Sept. 29, 7 p.m.
LINCOLN
"How the Production Engineer Can Be Helped by the Metallurgist," by Dr. J. D. Jevons. Lincoln Section. Ruston Club, Unity-square, Lincoln. Thurs., Sept. 30, 7.30 p.m.
LUTON
"Applications of Photography in Industry," by W. Harvey. Luton Section. Town Hall, Luton. Tues., Sept. 28, 7.15 p.m.
SHREWSBURY
"Carpet Manufacture," by C. Dobson, with film. Shrewsbury Section. Technical College, Shrewbury. Wed., Sept. 29, 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
"Forty Years with Rubber," by E. H. Wallace. Manchester Section. Engineers' Club, Albert-square, Manchester. Mon., Sept. 27, 6.15 p.m.

Institution of Structural Engineers

LONDON
Presidential Address by Dr. S. B. Hamilton. Thurs., Oct. 7, 6 p.m.

Junior Institution of Engineers

LONDON
"Prestressed Concrete Methods," film, introduced by C. E. Reynolds. Fri., Oct. 1, 7 p.m.

Manchester Association of Engineers

MANCHESTER
Inaugural Address by the President, S. N. Clift. Engineers' Club, Albert-square, Manchester. Fri., Oct. 1, 6.45 p.m.

Women's Engineering Society

MANCHESTER
"Health in Industry," by Dr. M. W. Robinson. Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., Sept. 29, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Engineering Designers, Grand Buildings, Trafalgar-square, London, W.C.2. (WHItehall 2489.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 20 Booth-street, Manchester, 2. (Central 2796.)
Women's Engineering Society, 35 Grosvenor-place, London, S.W.1. (SLOane 0401.)

Labour Notes

WELFARE MAY BE OVERDONE

The view that welfare arrangements at some works and factories may be over-elaborate was put forward by Mr. John Marsh, director of the Industrial Welfare Society, in the course of an address at a recent conference in London.

He stated that, in his opinion, there was considerable doubt whether the majority of workpeople really desired many of the outside activities provided for them by their employers.

Mr. Marsh, who was speaking on work and leisure, said he believed that the modern tendency to appoint full-time Government officials to perform welfare activities previously done by voluntary effort had definite long-term disadvantages.

If the nation desired to hasten the coming of an age of greater leisure, provision should be made for that leisure to be rendered purposeful.

DOCKERS' CHANGE OF UNIONS

It appears that some 2,700 of the 4,000 dockers at Hull have completed application forms to join the National Amalgamated Stevedores and Dockers and a mass meeting of members of the union at Canning Town on September 14 decided that these applications be accepted.

This decision was confirmed by the union's national executive committee on September 17 after a private meeting of several hours' duration. It was also decided that an office should be opened by the union at Hull, on Monday last, to receive applications for membership, and to admit formally dockers to the union.

The Hull dockers, it is understood, are to have direct representation on the union's national executive committee. In a statement after the mass meeting on September 14, Mr. W. Newman, the assistant general secretary of the union, said that it was expected that at least half of the 1,300 Hull dockers, who have not so far completed application forms for the N.A.S.D., would eventually wish to join the union.

There had been a request for two thousand application forms from dockers at Birkenhead. Men employed there, or at other British ports, who asked to join the union, would doubtless have their wishes favourably considered.

It was announced on Sunday that some 800 Birkenhead dockers had applied to join the N.A.S.D., following a meeting at Birkenhead Town Hall on that day.

DIFFICULTIES, PAST AND PRESENT

The Transport and General Workers' Union, which has been, hitherto, the only union to represent dockers at Hull and Birkenhead, is thus confronted with the threat of a serious secession among its dock membership.

Although the trouble seems to have been brought to a head mainly during the recent strike at Hull, difficulties between certain sections of dock employees and the T.G.W.U. appear to have existed, intermittently, for some years. They may even date back to 1923 when, following a dock strike in that year, the stevedores' union changed its name to National Amalgamated Stevedores and Dockers and altered its rules so as to enable dockers to become members.

Similarly, in the 1930s, dockers employed on Clydebank left the T.G.W.U. after a strike and formed the Scottish Transport and General Workers' Union.

During the years since the last war, there have been various expressions of dissatisfaction among dockers regarding the T.G.W.U., mainly, it seems, on the ground of the size of the union or on that of the wide scope of its membership.

The creation of union officials by appointment, instead of by election by the rank and file, has been given as a source of irritation to some dock workers, as has also the alleged absence of "militancy" on the part of the union's leaders. There have been reports of the lack of information among the rank and file concerning the progress of events, and of irritation regarding alleged delays in dealing with complaints.

There seems little doubt that some sections of dock employees would like to see the formation of a union of their own, devoted exclusively to dockers and their welfare. The difficulties, however, of establishing a new union from scratch are indeed formidable. Apart from the entire absence of funds, there is the difficulty of obtaining recognition and negotiating rights.

LEVY ON DOCK EMPLOYERS REDUCED

Registered port employers have received notice from the National Dock Labour Board that the levy paid to the Board by the employers on the gross wages of their employees will be reduced as from October 9. The purpose of the levy is to provide funds for bringing up the men's wages to the guaranteed minimum rates during slack periods.

The reductions decided upon by the Board are: from 16½ to 14½ per cent. for daily operatives employed on work other than coastal traffic; from 11½ to 10½ per cent. for daily operatives employed on coastal traffic; and from 5 to 4½ per cent. for weekly operatives, whether employed on coastal or other work.

A deduction, from 22½ to 16½ per cent., in the levy on daily operatives employed on work not connected with coastal traffic, was made in August, 1953. The cost of operating the dock labour scheme amounted to £4,410,000 during 1953, compared with £5,296,000 during the previous year.

The lower cost last year was due to improvements in trade and to fewer men being retained on the Board's registers. The Board points out that the stability of the levy depends ultimately on the effectiveness of its labour policy and, in this connection, the Board pays a tribute to the valuable co-operation it has received from local Boards, and the dock industry generally, in its efforts to achieve a more flexible and balanced labour force.

WASTAGE OF AGEING EMPLOYEES IN THE BUILDING TRADE

Suggestions that building-trade employees in their early sixties succumb to a kind of "creeping" wastage are made by F. Le Gros Clark in a report to the Nuffield Foundation on the working fitness of men in the industry aged 60 and above.

The level of wastage, he considers, will decline only so far as the medical treatment of old age advances, or ageing men can be rehabilitated, or methods of production can be fitted to a man's physical capacity. In many cases, it may be necessary to provide alternative work, usually of a lighter character. Work of this nature, however, is not plentiful and he recommends that a survey should be undertaken in this field.

As the result of studying 315 building-trade employees in many parts of the country, Mr. Le Gros Clark has reached the conclusion that any body of men in the industry attaining their sixties in a fair state of efficiency would most likely have suffered a wastage of nearly 40 per cent. of their number by the time they had passed their mid-sixties. A great part of this wastage would be due to what Mr. Le Gros Clark describes as "industrial senescence."

Throughout his investigations, there always seemed to be some men in their early sixties who were on the verge of true industrial old age. In number, they ranged from about 20 per cent., in the case of craftsmen, to nearly 30 per cent., in the case of labourers. The report is the second to the Nuffield Foundation on this subject.

BUILDERS' RELUCTANCE TO USE NEW METHODS

The view that progress in the building industry has been too slow in some ways is expressed in the latest issue of *Getting Together*, a publication dealing with productivity in British industry during the years since the end of the last war.

It is recognised that the national organisations of the various sections of the industry, as well as many individual firms, are fully aware of their responsibilities. At the same time, the brochure considers that there is a general feeling that much too little appreciation is shown in some quarters of the necessity for abandoning, even experimentally, the traditional methods of centuries, and for introducing new ideas and materials.

The importance of team work, planning in advance, and the standardisation of methods and materials, cannot be emphasised too strongly.

The brochure, which is the sixteenth in the series, is published by the British Productivity Council, 21 Tothill-street, London, S.W.1.

DECLINE IN COST-OF-LIVING INDEX

There was a decline by one point in the level of the cost-of-living index during the monthly period ended August 17, according to an announcement by the Ministry of Labour and National Service on Monday.

The figure for August 17 was 144, compared with 145 on July 20, and 140 in mid-August last year. It may be recalled that, during the two years between June, 1952, and June, 1954, there was an increase of only four points in the index, from 138 to 142, and that, for several months last year, and during the early part of this year, the index figure remained stationary at 140.

Decreases in vegetable prices, the Ministry points out, were the cause of the recent fall of one point; but the reductions were partly offset by increases in the prices of milk, eggs and meat.

The present index was commenced on June 17, 1947, the level at that date being taken as 100.

REDUNDANCY STRIKE BY ELECTRICIANS AT LONDON DOCKS

Difficulties arising from the dismissal of five men in the employ of R. and H. Green and Silley Weir, Limited, Blackwall Yard, London, led to suggestions that some 500 men engaged on electrical-repair work, on ships at the Port of London, should cease work as from 5 p.m. on Monday.

It was claimed that the men concerned, who are members of the Electrical Trades Union, were dismissed out of turn and that the custom of dismissing first men who were engaged last had been broken.

A statement issued by the joint shop stewards' council of the Port of London stated that the council had decided to give full support to the electricians, in the event of strike action taking place. The council would recommend its members to refuse to operate any machinery controlled by electricity at the port, "whether it be permanent, portable or temporary."

At a subsequent meeting of the shop stewards' council on Monday, the decision to support the electricians was confirmed. A meeting with the employers to consider redundancy in the ship-repairing industry was requested. The dispute, which is unofficial, may affect the whole London area.